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Periodontal Disease in Young Adults

Klaus E. Anerud

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Klaus E. Ånerud

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PERIODONTAL DISEASE IN YOUNG ADULTS

Presented by

Klaus E.Ånerud D.D.S.

Major Adviser ______________________
Harald Löe D.D.S., Dr. Odont.

Associate Adviser ______________________
Paul B. Robertson D.D.S., M.S.

Associate Adviser ______________________
Clarence L. Trummel D.D.S., Ph.D.

Associate Adviser ______________________
Robert M. Rippey Ph.D.

The University of Connecticut

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INTRODUCTION

Numerous epidemiological studies show that diseases of the periodontium are among the most common afflictions of mankind. The predominant periodontal diseases are gingivitis and periodontitis. Both are caused by bacterial plaque (Löe, Theilade & Jensen 1965, Saxe et al. 1967, Lindhe, Hamp & Löe 1973). Gingivitis, an inflammatory reaction confined to the gingiva, is characterized clinically by increased redness, enlargement, altered consistency and tendency to bleed upon manipulation. The general view is that this inflammation left untreated will likely progress in an apical direction resulting in periodontitis, with destruction of periodontal connective tissue, loss of alveolar bone, epithelial migration along the root surface and pocket formation. The progression of this lesion may eventually lead to tooth hypermobility and finally, tooth loss. For unknown reasons, gingivitis may in some cases persist without further involvement of the periodontium. Thus, whether gingivitis is an early stage of periodontitis or a separate entity is not known. Nevertheless, numerous studies suggest that periodontitis does not occur in absence of gingival inflammation.

The prevalence and severity of periodontal disease have been reported for different age groups and populations all over the world, and several reviews of its epidemiology have been presented (Löe 1963, Sherp 1964, Waerhaug 1966, Chilton 1977). In general, gingivitis is commonly found in the primary and permanent dentition in children and affects most adults. Although loss of attachment is rarely found in children, the prevalence of periodontal pockets and alveolar bone loss increases in teenagers. After the age of 20, periodontal destruction progresses with increasing age in a nearly linear fashion. The progression of periodontal disease will in most cases result in extensive periodontal destruction, the main cause of tooth loss in adults (Waerhaug 1966, Johansen 1970).

The natural history of periodontal disease has been described longitudinally in Norway and Sri Lanka (Löe et al. 1978 a,b,c, Ånerud et al. 1979). This study demonstrated that the rate and pattern of periodontal destruction varied not only between populations, and among different individuals but also among different sites in the same individual. The mean rate of periodontal destruction was 0.09 mm. per year in the Norwegian population with good oral hygiene, and 0.25 mm. per year in the Sri Lankan population with poor oral hygiene. In both populations, loss of attachment was commonly found first on lower central incisors and first molar areas, but eventually affected all teeth. Periodontal destruction primarily involved interproximal areas in the Sri Lankan population. In Norway, loss of attachment was found more frequently and progressed at a higher rate on buccal sites than on interproximal sites.

Previous epidemiological studies, particularly of United States populations, have primarily concentrated on children below the age of 12 years or adults over the age of 40. Limited information is available for young adults with respect to loss of attachment, recession and exogenous factors. The primary reason for this lack of information is probably based on early studies suggesting that little or no periodontal destruction was present before age 30. Thus, the value of studying young populations was thought to be limited. In general, previous studies have used poorly defined, relatively insensitive methods for assessment of periodontal destruction. These methods were sufficient for description of large populations with severe periodontal disease, but of limited value in populations with mild or moderate destruction. Furthermore, previous studies have often used different measurement criteria, making it difficult to compare one study to another. The objective of this study was to assess periodontal destruction and related etiological factors in young adult United States males employing methods previously used for similar groups in Norway and Sri Lanka.

LITERATURE REVIEW

A. Periodontal Indices

Many investigations conducted during this century have attempted to assess the extent of periodontal diseases and related etiological factors. Prior to the 1940's, gingival and periodontal disease was either characterized as "present" or "absent", or described according to the tissue condition, "good", "fair" or "poor." Black (1918) studied periodontal disease in 600 adults, 20-50 years old. Areas were classified as being affected with periodontal destruction or not, depending on presence or absence of radiographic evidence of alveolar bone loss. Other authors suggested different methods for measuring gingival inflammation (Ainsworth 1925, King 1945) and periodontal destruction (Sheppard 1936, Schwartz 1946). In general the criteria used were arbitrary and coarse, which made calibration of investigators and interpretation of data difficult. A more precise evaluation of gingival status was proposed with the introduction of the P-M-A Index (Schour & Massler 1947, Massler, Schour & Chopra 1950, Massler, Ludwick & Schour 1952). This was the first attempt to articulate well defined criteria for assessment of gingival inflammation. The index was based on the assumption that gingival inflammation started in the papilla (P), spread to the marginal area (M) and in severe cases continued to the attached gingiva (A). The gingiva of lower anterior teeth were used to indicate the general condition of the whole mouth.

Presence of inflammation and its severity were recorded separately for each gingival area. Scores were given on a scale from 0 to 5 for papillary units and from 0 to 3 for the marginal and attached gingiva. In spite of its high degree of sensitivity this index had some shortcomings. The complexity of the index made scoring according to the criteria difficult, and in addition this index did not evaluate the status of the gingival pocket by direct measurement. The index was developed to assess gingival status in children, but has also been used in epidemiological studies of adult population groups (Massler et al. 1957). The PMA Index was used as basis for development of other indices. Mühlemann and Mazor (1958) suggested assessment of inflammation in only papillary and marginal areas of the gingiva, since involvement of attached gingiva was rare. Areas were scored on a scale of 0 to 4. Mühlemann and Son (1971) suggested a modification of the PM Index termed the Sulcus Bleeding Index (SBI) which scored gingivitis on a scale of 0 to 5. Both the PM Index and Sulcus Bleeding Index used bleeding on probing as the criteria for slight inflammation, and gave highest scores for color changes and tissue swelling. The validity of this assumption will be discussed later.

During the late 1950's and early 1960's, the World Health Organization supported a series of epidemiological studies on periodontal disease. The Periodontal Index (PI; Russell 1956) was introduced for these studies to evaluate both gingival inflammation and periodontal destruction. This index measured gingival inflammation, pocket formation and loss of masticatory function according to the following criteria:

Score

0 = Negative

There is neither overt inflammation in the investing tissues nor loss of function due to destruction of supporting tissues.

1 = Mild Gingivitis

There is an overt area of inflammation in the free gingivae, but this area does not circumscribe the tooth.

2 = Gingivitis

Inflammation completely circumscribes the tooth, but there is no apparent break in the epithelial attachment.

6 = Gingivitis With Pocket Formation

The epithelial attachment has been broken and there is a pocket (not merely a deepened gingival crevice due to swelling in the free gingivae). There is no interference with normal masticatory function; the tooth is firm in its socket, and has not drifted.

8 = Advanced Destruction With Loss of masticatory function

The tooth may be loose; may have drifted; may sound dull on percussion with metallic instrument; may be depressible in its socket.

The Periodontal Index is probably the most widely used method in epidemiological evaluation of periodontal disease. It is relatively insensitive to initial signs of disease. Since probing is not done, only obvious gingival conditions are detectable. Periodontal destruction in this index can be graded only as initial periodontitis (score 6) or total periodontal destruction (score 8). Therefore, this method will tend to underestimate the degree of periodontal breakdown. The Periodontal Index is best suited for description of populations with advanced periodontal disease. However, in populations with mild or moderate periodontitis its use is less valuable.

In an attempt to address some of these problems, Ramfjord (1959) developed the Periodontal Disease Index (PDI). Six teeth (maxillary right first molar, left central incisor and left first premolar, and mandibular left first molar, right central incisor and right first premolar) were used to represent the whole dentition. To obtain more accurate measurements of periodontal destruction, attachment loss was measured by probing from the cemento-enamel junction to the bottom of the pocket. To assess gingival recession, the distance from the cemento-enamel junction to the gingival margin was measured. A probe graded in 3 mm increments was used. Criteria for the index are as follows:

Score	
	Gingival crevice does not extend to CEJ
0 =	Absence of signs of inflammation.
1 =	Mild-to-moderate inflammatory gingival changes, not extending around the tooth.
2 =	Mild-to-moderately severe gingivitis extending all around the tooth.
3 =	Severe gingivitis characterized by marked redness, swelling, tendency to bleed and ulceration.
	Gingival crevice extends apically to CEJ
4 =	Gingival crevice extends apically to the cemento-enamel junction but not more than 3 mm.
5 =	Gingival crevice extends apically to the cemento-enamel junction from 3 to 6 mm (including 6 mm).
6 =	Gingival crevice extends more than 6 mm apically to the cemento-enamel junction.

The index had several disadvantages. All measurements less than 0.5 mm were rounded to the lower whole number. Therefore, this index slightly underestimated periodontal destruction. Since the cemento-enamel junction must be located to assess loss of attachment this method often required the time consuming removal of calculus. Since the PDI scores are based on spatial measurements for scoring of periodontal disease, the PDI is probably a more accurate system. However, the validity of combining gingival inflammation and periodontal breakdown into one score, as in both the PI and PDI, is questionable, since the degree of gingival inflammation may be unrelated to the severity of periodontal destruction. In spite of these shortcomings, the PI, like the PDI, proved useful for characterizing large populations with advanced periodontal disease. Both indices were used during the late 1950's and early 1960's in a series of epidemiological studies in Asia, Europe, South America, Africa, the United States and the Far East sponsored by the World Health Organization, and much of our present knowledge concerning the epidemiology of periodontal disease is based on these studies.

A different method for assessing periodontal destruction was suggested by Sandler and Stahl (1959) to assess periodontal disease rate (PDR) by the formula $PDR={}^{a}/a+b$, where "a" represented number of teeth affected by periodontal disease and "b" was number of healthy teeth. Although this method represented a simple measurement of periodontal disease prevalence, it merely assessed the presence or absence of disease and did not distinguish between different degrees of periodontal breakdown. Thus, it is probably of limited value in adult populations with a high prevalence of periodontal disease, since assessment of severity is necessary for a sufficient description of the individual or population.

Since a large number of epidemiological studies suggested a strong relationship between the presence of plaque, calculus and periodontal disease, Ramfjord (1959) proposed an index for evaluation of plaque and calculus. Calculus was scored on the basis of the following criteria:

0 = Absence of calculus.

1 = Supragingival calculus extending only slightly below the free gingival margin (not more than 1 mm).

2 = Moderate amount of supra- and subgingival calculus on subgingival calculus alone.

3 = An abundance of supra and subgingival calculus.

Since it was recognized that subgingival calculus was probably a more important factor than supragingival calculus in the pathogenesis of periodontal disease, the higher score (2) was given for presence of subgingival calculus. This method has been used widely in epidemiological studies. After application of disclosing solution, plaque was scored as present or absent on interproximal, buccal and lingual surfaces on a scale from 0 to 3. Schick and Ash (1961) modified the Ramfjord plaque index by excluding interproximal areas and scoring only stainable plaque on facial and lingual surfaces. Since disclosing solution is required, these plaque indices are of limited value in epidemiological studies.

Greene and Vermillion (1960) introduced the Oral Hygiene Index (OHI) to assess the relationship between microbial deposits and periodontal disease. The fact that a system to quantitate plaque was not introduced until 1960, is a reflection of the state of the art at that time and may also explain the widespread ignorance in the general population regarding causative factors in periodontal disease which still exists today.

The Oral Hygiene Index has two components. One of these, the

Debris Index (DI), measures the area of tooth surface covered by supragingival plaque. The other component, the Calculus Index (CI), assesses both the coronal extension of supragingival calculus and the presence of subgingival calculus. The OHI was based on the assumption that the greater the tooth area covered by debris or calculus, the less efficient were tooth-cleaning practices. Using the OHI, Russell (1963) suggested that 90% of all periodontal disease could be related to debris and calculus accumulation. With increasing age, strong linear and parallel increases of both PI scores and OHI scores were found. The increase in OHI scores were the result of calculus accumulation, as reflected by higher CI scores with increasing age. However, to suggest that a correlation exists between supragingival plaque accumulation and periodontal destruction is probably not correct since supragingival plaque levels vary little with age (Ånerud et al. 1979)

To make the OHI more useful in epidemiological surveys Greene and Vermillion (1964) simplified the index. This modification was referred to as the Oral Hygiene Index Simplified (OHI-S). Using the following criteria only six tooth surfaces were scored to represent the whole mouth:

0 = No calculus present.

1 = Supragingival calculus not covering more than one-third of the exposed tooth surface being examined.

2 = Supragingival calculus covering more than one-third but not more than two-thirds of the exposed tooth surface, or the presence of individual flecks of subgingival

calculus around the cervical portion of the tooth.

3 = Supragingival calculus covering more than two-thirds of the exposed tooth surface or a continuous heavy band of subgingival calculus around the cervical portion of the tooth.

Debris was scored according to the same criteria. However, presence of subgingival debris was not measured. The major strength of OHI-S is its easy of use and the good correlation between OHI-S and PI. This has led to wide use of the OHI-S in epidemiological studies. A limitation of the OHI-S Index is that plaque is scored according to surface area covered. Thus, it does not reflect the fact that the mass of plaque at the gingival margin may be relatively more important for pathogenesis. Quigley and Hein (1962) presented an index that focused primarily on plaque accumulation in the gingival third of the tooth. Only the facial surfaces of anterior teeth were examined after application of disclosing solution. Turesky (1970) modified the Quigley-Hein Index to improve on the clarity of the criteria for scoring as well as to give even greater weight to plaque in the gingival third area. The technique was used on the facial and lingual surfaces of all teeth.

The Modified Navy Plaque Index (Elliot et al. 1972) also gives the highest scores for plaque adjacent to the gingival margin. This index, the Quigley-Hein Index and its Turesky modification all measure surface area covered by plaque and are probably of greater value in the clinical evaluation of oral hygiene in individual patients than for epidemiological studies.

A new era of periodontal research was started with the introduction of separate indices for scoring of plaque and gingivitis (Löe & Silness 1963, Silness & Löe 1964). Instead of combining gingival and periodontal indices as proposed by Russell and Ramfjord, the Gingival Index attempted to determine the degree of inflammation of the marginal gingiva. The Gingival Index (Löe & Silness 1963) divided the gingiva of each tooth into four units (mesial, buccal, distal and lingual). Scores were given on a scale of 0 to 3. A score of 0 represented health. Scores of 1, 2 and 3 represented mild inflammation without bleeding on probing, moderate inflammation with bleeding on probing and severe inflammation, respectively. The use of color change of the tissue as a criteria for early inflammatory change, and bleeding on probing as the sign of moderate inflammation is the reverse of criterion used in the Sulcus Bleeding Index (Mühlemann et al. 1971). The validity of the Gingival Index was supported by Oliver, Holm-Pedersen and Löe (1969), who demonstrated a good correlation between the histologic appearance and scoring according to this index. The Plaque Index (Silness & Löe 1964) determined thickness of plaque at the gingival margin, and no attention was paid to coronal extension of plaque as originally suggested for the OHI Index Greene et al.(1960). Using a pointed probe, scores were given from 0 to 3 for all teeth on all surfaces or on only selected teeth and surfaces. The plaque index has been used in both clinical studies and epidemiological studies. It is sufficiently sensitive to detect small changes in plaque levels. The reliability of the PlI has been supported by Lang, Østergaard and Löe (1972), who found a good correlation between PlI scores and plaque area measured photographically after staining.

Using the Plaque Index and the Gingival Index, Löe et al (1965) demonstrated a good correlation between plaque formation and initiation of gingivitis in humans. Subjects with initially healthy gingiva were followed over a twenty-one day period during which no plaque control was performed. All subjects developed gingivitis by the end of the experimental period. The development of this "experimental gingivitis" was highly correlated with the accumulation of cervical plaque. Reinstitution of oral hygiene resulted in a complete return to gingival health in all subjects within 10 days.

With the increased evidence that plaque and calculus were the prime etiological factors in periodontal disease, more sensitive indices were proposed to evaluate calculus accumulation. Ennever, Sturzenberger and Radlike (1961) developed the Calculus Surface Index (C.S.I.). Presence of calculus was scored on 4 surfaces on each of the mandibular incisors. The number of surfaces with calculus determined the C.S.I. score. In addition, Volpe and Manhold (1962 and Volpe, Manhold and Hazen (1965) described the Probe Method of Calculus Assessment. The lingual surfaces of six mandibular anterior teeth were examined using a probe calibrated in millimeters. Three measurements were used (gingival, mesial and distal) to quantitate calculus accumulation. Mühlemann and Villa (1967) described the Marginal Line Calculus Index to assess accumulation of calculus along the gingival margin of mandibular anterior teeth. These indices were designed for use in studies of calculus inhibitory agents and were of little value in epidemiological studies, since only supragingival calculus was assessed. To reduce the source of the subjective factors in assessment of periodontal destruction, several authors have proposed the use of radiographs in clinical and epidemiological studies. The Gingival-Bone-Count (Dunning & Leach 1960) was a measure of both gingival inflammation and alveolar bone level. Use of radiographs was recommended to assess level of alveolar bone crest. Gingivitis was scored on a scale of 0 to 3 and bone loss on a scale of 0 to 5. The average Gingival Score was added to the average bone score to yield the Gingival-Bone-Count. When evaluating this index and other indices that combine measurements of gingival inflammation and periodontal destruction into one resultant value, one should keep in mind that the results can not be expressed on a ratio scale. For instance a score of 4.0 may not be twice as severe as a score of 2.0. Thus interpretation of these types of indices can in many cases be difficult. To obtain more accurate measurements, Schei et al. (1959) introduced a plastic ruler with a graded scale to evaluate bone loss on radiographs, using the cemento-enamel junction as reference point. Marginal bone loss was expressed as fraction of total radiographic root length. Björn, Halling and Thyberg (1969) further developed this method by superimposing a graded scale on radiographs which were then projected onto a screen. Everett and Fixott (1963) introduced a technique in which wire grids were attached to the radiograph before exposure. Although radiographs provide good accuracy and reproducibility for measurements of bone levels in interproximal areas, they are of limited value in evaluating buccal and lingual bone levels. One reason for advocating use of radiographs in epidemiological studies has been the assumption that the data would be more accurate and reproducible than clinical measurements of attachment level. However, Suomi, Plumbo and Barbano (1968) were unable to demonstrate a significant difference between bone heights measured from radiographs and by probing before and after surgical exposure. This indicates that radiographs are useful for assessment of bone level, but clinical measurements of attachment level yield equally accurate assessment of periodontal destruction.

In epidemiological studies the use of unnecessary radiation should be carefully evaluated. Further, radiographs require more time, money and equipment than clinical examinations. Clinical assessment of periodontal attachment levels is the method of choice and radiographs may be considered valuable adjuncts.

The role of microbial plaque in the initiation of periodontal disease is now indisputable. It is also generally accepted that the plaque must extend subgingivally in this process. While there is no satisfactory index for assessment of subgingival plaque, rough subgingival surfaces invariably covered by bacterial plaque can be scored according to the Retention Index (Löe 1967). Supra- and sub-gingival calculus, imperfect fillings and caries are assessed according to location and extent, and are scored on a scale of 0 to 3. A score of 0 represents surfaces free of calculus, imperfect fillings or caries. Scores of 1 and 2 represent presence of calculus, caries or imperfect filling margins located either supragingivally (1) or subgingivally(2) . Scores of 3 reflect gross calculus deposits, filling defects or carious lesions. This index allows recording of surfaces where bacteria will likely accumulate in the gingival area and may be considered an indirect measure of plaque.

While epidemiological methods used during the 1950's and 1960's were able to demonstrate the high prevalence of periodontal disease and gave important information with respect to the etiology, some authors felt that the index systems used required highly experienced examiners. To meet the need for simpler yet reliable indices useful to the general practitioner in the assessment of periodontal disease and its etiological factors, several simplified indices were introduced. The Periodontal Treatment Need System (Bellini 1973) has been used in Norway for the purpose of screening individuals in need of periodontal treatment. Presence or absence of plaque and gingivitis, and presence of 5 mm or greater pockets were recorded for each quadrant of the mouth. Based on the findings patients were classified in four categories:

Class 0 - No treatment needed.

Class A - Motivation and oral hygiene instruction.

Class B - Scaling and removal of overhanging restorations.

Class C - Surgery.

This system may be valuable in evaluation of periodontal treatment need in populations, in assessment of costs and manpower needed for prevention and for the assessment of plaque and gingivitis in a clinic setting where criteria would be clear both to the practitioner and the patient.

Ainamo and Bay (1975) introduced the Visible Plaque (VPI) and the Gingival Bleeding Index (GBI). The indices were simplified modifications of the Plaque Index (Silness & Löe 1964) and the Gingival Index (Löe & Silness 1963). Occurrence of visible plaque or bleeding after probing was recorded for mesial, buccal and lingual surfaces of all teeth in the right quadrants of the dentition. The use of easily identified criteria like visible plaque and gingival bleeding is probably of great value in patient motivation. However it is important to keep in mind that no evidence exists to support the assumption that gingival units that bleed after probing are associated with greater periodontal destruction than inflamed gingival units that do not bleed after probing. Therefore, absence of bleeding may not reflect periodontal health. Surfaces without visible plaque may still harbor both supragingival and subgingival microorganisms. While the presence of plaque and periodontal disease are strongly correlated, no correlation has been demonstrated between the amount of plaque and the degree of periodontal disease. Therefore, a more sensitive scoring system may be of greater use in epidemiological and clinical studies.

This review of the literature shows that several indices exist for assessment of gingival inflammation, periodontal destruction and the related etiological factors. In general, all available methods distinguish between presence or absence of disease and presence or absence of exogenous factors. From a historical perspective, early index systems were primarily directed to the presence or absence of disease. These were modified to allow detection of small variations in periodontal disease or etiological factors. While the more sensitive index systems may generate more information, these methods generally are more cumbersome and present more difficulty in investigator calibration. Thus, different methods may be chosen for different situations. In studies of populations with poor oral hygiene and advanced periodontal disease, employment of less sensitive scoring criteria will probably be satisfactory. In populations where oral hygiene is good and only moderate periodontal disease exists, more refined methods may be needed to obtain satisfactory data.

All index systems have limitations. The validity of combining scoring of gingival inflammation and periodontal destruction into one index value is questionable. First, these may be different disease entities. Second no correlation has been demonstrated between the degree of gingival inflammation and periodontal destruction. Thus these two diseases should be separated when assessed.

When measuring gingival inflammation, plaque or calculus, most indices use a nonparametric scale. It is important to keep in mind that the difference between a score of 0 and 1 may not be the same as the difference between a score of 1 and 2. This reflects the difficulty of grading biological processes on a ratio scale.

B. Review of Epidemiological Studies of Periodontal Disease

1. Cross-sectional Studies of Children and Adults

In general, interpretation of epidemiological studies is complicated by deficiencies in indices used for measurement of periodontal disease and the assumption, made in most studies, that all pathology affecting the periodontium is a single entity. Nevertheless, despite a variety of experimental approaches using populations with divergent cultural, socioeconomical and geographical backgrounds, the results of epidemiological surveys have been remarkably uniform with respect to the universality of periodontal disease and the strong positive correlation between periodontal disease and both age and the presence of microbial plaque. Comprehensive reviews are provided by Löe (1963), Waerhaug (1966) and Chilton (1977).

The prevalence and severity of gingivitis in children has been widely studied. Massler et al. (1950) studied gingival conditions in United States children. At age 5, 9.1% of the subjects had gingivitis, and 80% of subjects 11 years of age had gingival inflammation. Parfitt (1957) found that 80-90% of English children 11-17 years old showed signs of gingivitis. Later studies from India (Greene 1960, Ramfjord 1961), Africa (Sheiham 1968, Poulsen, Möller & Naerum 1972), Norway (Jordkjend & Birkeland 1973), England (Sheiham 1969) and the U.S.A. (Jamison 1963) indicated that by age 10, essentially 100% of children had one or more inflamed gingival units. These studies also showed that the prevalence and severity of gingival inflammation increased with age during childhood, reaching its highest point during puberty. While the development of periodontitis in children is relatively uncommon, pocket formation and related bone loss has been described in teenage populations. Marshall-Day and Shourie (1949) found in a roentgenographic survey in India that 8% of the subjects showed signs of alveolar bone loss at age 13, while all subjects examined had lost alveolar bone at age 17. In the United States, the same authors (Marshall-Day, Stephens & Quigley 1955) reported that 4% of the subjects in the age group 13-15 showed radiographic evidence of bone loss. Russell (1971) reported similar figures for prevalence of periodontal pockets in 15-19 year old adolescents in the U.S.A. (3%), Thailand (4.8%) and Lebanon (11.4%). Reports from India (Ramfjord 1961) and Sweden (Hugosson & Koch 1979) demonstrated that 2% and 17%, respectively, of 15 year old children had periodontal pockets. In a more recent study from the United States (Mann et al. 1981), 25% of subjects 12-16 years old had one or more sites with loss of attachment of at least 2 mm.

The prevalence of juvenile periodontitis appears to vary greatly. Most authors agree that juvenile periodontitis is characterized by onset at puberty, minimal bacterial deposits, mild gingival inflammation, and rapidly progressing bone loss associated primarily with molars and incisors. Marshall-Day and Shourie (1949) reported that juvenile periodontitis occurred in 18% of subjects examined in India. Waerhaug (1967) surveyed more than 8000 individuals in Ceylon and was unable to find any cases of juvenile periodontitis. Ramfjord (1961) was also unable to detect juvenile periodontitis in a group of 1615 Indian school children. In studies of U.S. military personnel, the prevalence of juvenile periodontitis was less than 1% (Kaslick & Chasens 1968, Lacy & Basher 1977). Saxen (1980) found similarly low values in a Finnish teenage population.

The variation in prevalence figures in the above studies may reflect, to a great extent, the different methods and criteria employed for assessment of periodontal disease. In general, however, a low prevalence of periodontitis is found in adolescents, and when comparing studies using the same indices for disease measurement, lower scores are found for populations in the United States and Scandinavia compared to developing countries in Africa and Asia.

With increasing age, the prevalence of periodontitis increases, and from the age of 20 there appears to be a pronounced increase in the prevalence and severity of periodontal destruction. A common trend in the majority of epidemiological studies of periodontal disease is the high percentage of individuals that develop periodontal disease between the ages of 20 and 30, and by the age of 40, essentially all individuals have some degree of periodontal destruction. In 279 individuals examined by Marshall-Day et al. (1955) in the U.S.A., periodontal disease was found in 24% of subjects 19-22 years old and essentially 100% of the subjects had periodontal disease at age 35. In an investigation of industrial workers in Oslo (Lövdal, Arno & Waerhaug 1958), a similar picture was found. Hugoson and Koch (1979) reported an increase in subjects with periodontal pockets from 21% at age 20 to 56% at age 30. Waerhaug (1966) and Johansen (1970) concluded that periodontal disease was eventually responsible for the majority of tooth loss in the adult populations of all nations of the world.

Several studies suggest that males have more periodontal disease than females (Lövdal et al. 1958, Russell 1957). However, when comparing males and females of same age and oral hygiene level, no difference can be found (Lövdal et al. 1958). When comparing populations from different geographic areas, a clear difference is found between periodontal disease prevalence in Asian and African countries compared to the U.S.A. and Scandinavia. This might suggest a racial predisposition. However, when comparing negroes and whites in the U.S.A., no difference was found among subjects with equal levels of oral hygiene (Russell & Ayers 1960). Similiar results were reported in studies comparing periodontal conditions in Norwegian and Indian dental students (Johansen 1970).

Several studies have shown an improvement in periodontal condition with an increase in income and educational levels (Brandtzaeg & Jamison 1964, Lövdal et al. 1958, Russell 1960). The same studies also demonstrated that people with higher education and income have better oral hygiene, and thus these differences can be explained by oral hygiene levels.

In summary, periodontal destruction may occur in adolescents. The severity of periodontal disease increases with age. Prevalence and severity vary with geographic area, socioeconomic status and sex. These differences are also explained by different oral hygiene levels.

2. Longitudinal Studies of Periodontal Disease in Adults

The natural history of periodontal disease in man was first described by Löe, Ånerud, Boysen and Smith (1978). The study was started in Oslo, Norway in 1969 and in Sri Lanka in 1970. The two population groups were chosen in anticipation of large differences in oral hygiene level and rate of periodontal destruction. This was confirmed by baseline data reported by Löe et al. (1978a). The two groups also showed major cultural, socio-economic and educational differences, and represented extremes, in both general health care delivery systems and lifetime dental care. The Oslo group, consisted of 565 healthy male students and university teachers born between 1934 and 1952. The principal reason for selecting Oslo as a study site was that this city has preschool, school and post-school dental programs offering systematic preventive, restorative, endodontic, orthodontic and surgical therapy on an annual recall basis for all individuals 3-16 years of age. The documented attendance record for the last 40 years is 90%. The remaining 10% make use of services provided by private dental practitioners in the area. In addition, the city of Oslo offers a reimbursement plan for expenses incurred for dental services between 17 and 21 years of age, and the University, through the Student Health Services, provides a dental care program for students. The chosen population thus represents a group of individuals that has had maximum exposure to conventional dental care throughout its life.

The second group was established in Sri Lanka in 1970 and consisted of 400 male tea laborers between 15 and 30+ years of age. The participants were healthy by local standards and their nutritional condition was clinically fair. Subjects in this group had never been exposed to any programs relative to prevention or treatment of dental diseases. Tooth brushing was unknown.

Examinations of the Norwegian group were conducted in 1969, 1971, 1973 and 1975. The Sri Lankan population was examined in 1970, 1971, 1973 and 1977. At each examination, missing teeth were recorded. Scoring of mesial and facial surfaces of all teeth, except third molars, were recorded for the following indices:

Plaque Index (Silness & Löe 1964, Löe 1967)

Calculus Index (Ramfjord 1959)

Gingival Caries Index (Löe & Silness 1967)

Filling Margin Index (Löe 1967)

Gingival Index (Löe 1963, Löe 1967)

Loss of Attachment (Ramfjord 1959)

Intraexaminer reproducibility tests indicated that the examiners, Drs. A. Ånerud and H. Boysen, were consistent in their application of the criteria for the clinical measures of periodontal disease and exogenous factors (Löe et al. 1978a, Ånerud et al. 1979).

Descriptive studies have been completed for the age range of 14 to 40, and publications describe baseline data (Löe et al. 1978a), rate of periodontal destruction (Löe et al. 1978b), tooth mortality rate (Löe et al. 1978c) and changes in gingival health and oral hygiene (Ånerud et al. 1979) before 40 years of age. In general, the Norwegian group exhibited very low levels of plaque, calculus and gingival inflammation. Mean plaque scores ranged from 0.95 to 1.25 and 65% of all tooth surfaces had a score of 1 or less. Calculus occurred primarily on mandibular anterior teeth. Only 4% of total surfaces examined had subgingival calculus, found mainly in older age groups.

Mean Gingival Index scores ranged from 0.66 to 0.83. Approximately 35-40% of all tooth surfaces were scored GI=0, 50%, GI=1 and only 10%, GI=2. The mean loss of attachment was also quite low in the Norwegian group, ranging from 0.06 mm to 1.66 mm. In general, mean annual loss of attachment rates were greater for buccal surfaces than mesial surfaces, averaging 0.08 mm and 0.1 mm, respectively.

In Sri Lanka, plaque was found on almost all buccal and mesial surfaces of all teeth, and 91% of all surfaces scored Pll=2 or greater. Supra- and sub-gingival calculus was common, and mean calculus scores approached 2.0 in subjects that were 30 years of age. The mean Gingival Index scores ranged from 1.77 to 1.99, and the majority of all surfaces in all age groups scored GI=2 or greater. Mean loss of attachment for the Sri Lankan population was much greater than for the Norwegian group, averaging 0.40 mm at 19 years , 3.11 mm at 31 years and 4.5 mm by 37+ years of age. While all teeth showed loss of attachment, progressively worse lesions were observed on the interproximal and buccal surfaces of incisors and molars.

3. Cross-sectional Studies of Young Adult Populations

In general, epidemiological studies of periodontal diseases have focused primarily on teenage populations and adult groups over the age of 30, while relatively few studies have reported on young adult groups.

Studies from the U.S.A. show great variation in prevalence and severity of gingivitis, periodontitis and measures of etiological factors. Belting, Massler & Schour (1953) found that 92% of examined males 20-24 years of age were free of disease. Conversely, Marshall-Day et al. (1955) found in a corresponding age group, a prevalence of gingivitis and periodontitis of 76% and 24% respectively. The same authors reported that gingival recession and subgingival calculus were not common before age 19, but increased thereafter and by 30 years of age, 16% of subjects had gingival recession and 5% had subgingival calculus. Russell (1957) reported on periodontal conditions in urban U.S.A. populations and found that 8.9% of individuals 20-29 years had periodontal pockets. A higher value (16.8%) was reported by Ormes and Sheridan (1965) for a similar age group. Lightner et al. (1967) examined oral conditions in 713 U.S. Air Force cadets aged 17 to 21. This study demonstrated that 60% of the subjects had loss of attachment on one or more sites. Highest scores for calculus, gingivitis and loss of attachment were found in the lower anterior region, while highest plaque scores were found in maxillary posterior segments. O'Leary et al. (1968) reported on prevalence of gingival recession in the same group. Recession was found in 28% of individuals examined and occurred most frequent in maxillary posterior areas. In general, subjects with gingival recession were found to have less plaque than subjects without gingival recession.

Suomi and Doyle (1972) examined the periodontal status in 1127 industrial workers. Mean loss of attachment was 0.25 mm in the 20-24 year olds and 0.40 mm in the 25-29 year olds. Calculus scores increased with age, while gingival scores did not change between the groups.

In a study of Norwegian industrial workers Lövdal et al. (1958) found that less than 3% of individuals aged 20-25 had periodontal pockets. Both periodontal pockets and subgingival calculus were most common on interproximal surfaces and at age 25-35, 88% of examined surfaces had subgingival calculus. In a study of Norwegian army recruits, age 19-25, Brandtzaeg and Jamison (1964) found periodontal pockets in 35% of examined subjects while Kristoffersen (1970) reported that only 13% of soldiers in a similar age group had periodontal pockets.

In a study comparing periodontal conditions in 70 Norwegian and 230 Indian dental students (Johansen 1970), a clear difference was found both with respect to oral hygiene and periodontal condition. The Indian students had high calculus scores and debris scores, whereas essentially no calculus was present and oral hygiene was good in the Norwegian group. Seven percent of Norwegian students and 23% of students in India had periodontal pockets. In both populations, the highest Periodontal

Index scores were found in mandibular teeth. In India, the highest scores were found in mandibular molars and incisors and the lowest scores in maxillary anterior teeth. In Oslo, highest scores were found for mandibular molars and lowest for maxillary and mandibular incisors.

In a study of dental treatment need in Finish university students, Scheinin, Honka and Kankkunen (1970) assessed plaque (Silness & Lõe 1963), gingivitis (Lõe & Silness 1964) and presence of radiographic bone loss for selected teeth in 394 subjects, ranging in age from 19 to 34. Mean plaque and gingival scores were low, (0.87 and 0.67, respectively), and alveolar bone loss was found in 56% of the subjects, often associated with the presence of calculus or overhanging restorations. In a study of 848 English army recruits (Milne 1967), gingival bleeding was found in 70% of subjects and periodontal pockets were observed in 45% of individuals. Sheiham (1969) reported that 75% of British males, 20-24 years of age, had pocket formation.

Hugoson and Koch (1979) reviewed the oral condition in 1000 Swedish individuals. At age 20, 21% of individuals examined had periodontal pockets and by age 30, 56% had measurable pocket depth. In these subjects, bleeding on probing was found in 35% and 24% of examined sites in the 20 and 30 year old groups, respectively. In the 30 year olds, 30% of surfaces had visible plaque, and approximately 40% of sextants examined demonstrated subgingival calculus.

Waerhaug (1967) studied the prevalence of periodontal disease in Ceylon and found that oral hygiene and gingival and periodontal health were better in subjects with good education and/or higher income than in subjects with lower income and poor education. Lang, Cummings and Löe (1977) described oral hygiene and gingival health in Danish dental students and faculty. Lowest plaque and gingival scores were found in individuals with high exposure to preventive dentistry. In general, highest plaque scores were found in posterior areas and lowest in anterior areas. Facial surfaces had less plaque than interproximal surfaces, and in first-year students, more than 90% of interdental surfaces examined harbored plaque in the gingival area.

During the last 20 years, research efforts have resulted in considerable knowledge of the etiology of periodontal diseases and the development of measures which may be successful in their prevention. As a result, dentistry has changed from a primarily mechanical, reparative approach toward a greater emphasis on prevention. The foregoing discussion, however, indicates that little information is available to assess the effect of these delivered dental services. This is particularly true in young adults in the age range of 19 to 30. Moreover, those studies that are available have used widely variable measurement criteria for the assessment of exogenous factors, gingivitis and periodontitis. Consequently, a survey of the periodontal condition in young adult groups was designed, employing criteria used in similar populations in Norway and Sri Lanka.

GENERAL OBJECTIVE

The general objective of this study was to assess the prevalence and severity of periodontal disease and related etiological factors in a young adult United States males employing methods previously used for similar groups in Norway and Sri Lanka. The investigation should provide detailed knowledge of the pattern and severity of initial periodontal disease in young adults. This information may be useful in understanding the relative importance of related exogenous factors. Furthermore, the measures of exogenous factors, gingivitis and periodontitis in these young age cohorts may clarify those factors of importance in the initial stages of periodontal diseases. The information should also be important in evaluating the need for treatment in different populations or age groups, the frequency of dental care necessary to maintenance of periodontal health and may be an indicator of the general efficacy of current modes of dental services.

SPECIFIC OBJECTIVES

1) To survey in young adult (19-30 years) United States males:

   a) indices of etiological and retention factors, including plaque, calculus, and defective restoration margins and carious lesion in contact with the gingiva; and

   b) indices of periodontal health and disease including gingivitis, loss of attachment and gingival recession.

2) To compare these findings with reported results of cross-sectional studies in Norway and Sri Lanka and to determine the pattern of distribution and severity of plaque, calculus, defective fillings, gingival caries, gingival inflammation, loss of attachment and gingival recession in the three populations.

3) To describe interrelationships among these clinical characteristics of periodontal diseases and exogenous factors in three populations.

MATERIALS AND METHODS

Populations

The three populations included in this study were comprised of 113 individuals from Connecticut, U.S.A., 370 subjects from Oslo, Norway and 182 subjects from Sri Lanka as outlined in Table 1. All subjects were asked to participate on a voluntary basis. All subjects were males, in general good health, and ranged in age from 19 to 30 years. Subjects were either university students or had completed college/university education. The United States population consisted of caucasian students enrolled at the University of Connecticut. The majority of these subjects lived near the University campus at Storrs, Connecticut.

The Norwegian population has been described in detail by Löe et al. (1978a).

The Sri Lankan subjects were Burger, Singhalese and Thamil students enrolled in Universities located primarily in the cities of Kandy and Colombo. All subjects were examined at their respective Universities.

Data Collection

Prior to the clinical examination of United States subjects, data was obtained regarding age, residence, general health, smoking habits, oral hygiene habits, time since last dental visit and exposure to orthodontic treatment. All responses were entered on the same form used for collecting the clinical data.

Examination of the United States population was carried out during the spring of 1982. The Norwegian population was examined in 1969 and the Sri Lankan group in 1970, 1971, and 1973. The examinations in Norway and Sri Lanka were conducted by two investigators (Dr. Å. Ånerud and Dr. H. Boysen), and the exams in the U.S.A. were conducted by the present investigator. Inter-examiner error for the investigators involved in studies of the Norwegian and Sri Lankan population has been reported (Löe et al. 1978b, Ånerud et al. 1979) and indicated that the examiners were consistent in application of criteria for all indices. To assess inter-examiner error associated with the present study, 14 randomly selected subjects were examined by all three investigators using procedures described in following sections. Intraexaminer error was assessed by reexamining 8 subjects within a 24 hour period for each of the proposed indices. Table 20 shows inter-examiner agreement for all employed indices. Inter-examiner agreement was in general good for all indices and best agreement was found when scoring according to the Retention Index System (Löe 1967). Slightly lower percentage agreement was reached for PlI, GI and LA scores. When scoring attachment loss, perfect agreement was found in 70.5% of areas examined and 96.6% of scores were within 1 mm (Table 22). As shown in Table 21, intra-examiner agreement was good to excellent for all indices. Agreement for loss of attachment measurements within 1 mm was found in 97.8% of examined areas.

All dentitions were examined starting with the maxillary right second molar and ending with mandibular left second molar, a total of 28 teeth. All four gingival surfaces were examined in the U.S.A., while in Norway and Sri Lanka only mesial and buccal surfaces were examined. The surfaces were dried with air and all examinations were conducted with a mouth mirror and artificial light.

The Plaque Index (PlI; Silness & Lōe 1964) was based on the following criteria:

0 = No plaque in the gingival area.

1 = A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may only be recognized by running a probe across the tooth surface.

2 = Moderate accumulation of soft deposits within the gingival pocket, on the gingival margin and/or adjacent tooth surface, which can be seen by the naked eye.

3 = Abundance of soft matter within the gingival pocket and/or the gingival margin and adjacent tooth surface.

Interdental areas were examined from oral and facial aspects and the greater index value was assigned to the mesial or distal surface in question.

Retention Indices (Bjōrby & Lōe 1967, Lōe 1967), which assessed calculus (CI), gingival caries (CaI) and presence of imperfect margins of fillings or crowns (FI) in the gingival area was assessed according to the following criteria:

0 = No caries, no calculus, no imperfect margin of dental restoration in a gingival location.

1 = Supragingival cavity, calculus or imperfect margin of dental restoration.

2 = Subgingival cavity, calculus or imperfect margin of dental restoration.

3 = Large cavity, abundance of calculus or grossly insufficient marginal fit of dental restoration in a supra-and/or subgingival location.

The Gingival Index (Löe & Silness 1963) was performed based on the following criteria:

0 = Normal gingiva.

1 = Mild inflammation-slight change in color, slight edema. No bleeding on probing.

2 = Moderate inflammation - redness, edema and glazing. Bleeding on probing.

3 = Severe inflammation. Marked redness and edema. Ulceration. Tendency to spontaneous bleeding.

Surfaces were dried with air and surveyed with a mouth mirror. Areas with severe inflammation were assigned index values of 3. After inspection, the gingival margin was probed with a blunt probe. If bleeding occurred, a index value of 2 was assigned. Areas with pathological findings that did not bleed upon probing were given a score of 1 and healthy sites 0. All examined surfaces were evaluated both perpendicular and parallel to the long axis of the tooth. Interproximal areas were judged from oral and facial aspects and the highest score was assigned.

Loss of attachment was determined as described by Ramfjord (1959) by measuring the distance from the cemento-enamel-junction to the bottom of the gingival pocket. Interproximal sites were measured from the facial aspect of the contact point parallel to the long axis of the tooth. For facial and lingual measurements, premolars and anterior teeth were assessed on the mid-facial and mid-lingual surface. Molars were evaluated on the mid-facial aspect of the mesial-buccal root and on the mid-lingual aspect of the palatal root. Using this method, and measuring to the nearest mm, consistently high accuracy and reproducibility can be obtained (Glavind & Löe 1967).

Gingival recession (GR) was measured from the free gingival margin to the cemento-enamel-junction in mm. This measurement was only done in the U.S. population. All measurements were made on the same surfaces and sites as loss of attachment.

All three populations were examined in well equipped facilities with compressed air, artificial light and saliva ejectors. The sequence of examination was always the same and measurements were accomplished in the following order: plaque (PlI), calculus (CI), fillings (FI) and caries (CaI) were first assessed using a pointed probe, then gingival inflammation (GI), loss of attachment (LA) and gingival recession (GR) were measured using a blunt probe with a diameter of 0.6 mm calibrated with 1,2,3,4,5,7,9,11 mm markings. The same probes were used in the examination of all three populations and attempts were made to maintain a probe pressure of 30 g when the attachment level was measured. Probe pressure was evaluated using a Sartorius laboratory scale. All scores were recorded by a chairside assistant. In the case of a complete dentition, a total of 336 mesial and buccal surfaces were examined in Norway and Sri Lanka. In the United States all mesial, buccal, distal and lingual surfaces were examined. Thus, in the case of a complete dentition, a total of 784 surfaces were examined.

Statistical Analysis

All findings were recorded on specially designed charts which are included in the Appendix. Data from the three groups were entered into the H-88 (Zenith) computer in the Department of Periodontology, University of Connecticut School of Dental Medicine. Data entry was facilitated by programs written in Microsoft Basic which allowed entry, editing and storage of findings for each individual.

Means, standard deviations and frequency distributions were calculated for all indices in each age cohort of the three populations. Separate values were calculated for mesial and buccal surfaces for each tooth and summarized for the whole dentition in all age groups.

Inter-examiner and intra-examiner agreement was tested employing Kappa statistics as described by Cohen (1960). All Kappa values were statistically significant ($p<.001$) for all indices, indicating excellent agreement.

To evaluate the effect of the uneven distribution of subjects among age groups in the Sri Lankan population, 15 subjects were selected at random from the 21-22 years and 23-24 years groups. These selected scores for plaque, calculus, gingivitis and loss of attachment were not statistically different from total group scores.

RESULTS

Plaque

Mean values and frequency distributions of plaque scores are shown in Figure 1 and Tables 2 and 3. Plaque scores remained almost constant from age 19 to 30 in the three groups. The highest PlI scores were found on mesial surfaces and the frequency distribution of plaque scores greater than 1 indicated that interdental cleaning was, in general, inadequate in all three populations. Sri Lankans had the highest plaque scores and Norway the lowest plaque scores for interdental areas, and as shown in Table 4, 50.3% (Norway), 65.1% (U.S.A.) and 91.7% (Sri Lanka) of examined mesial surfaces had visible plaque. Few PlI scores of 0 were found on mesial surfaces in all populations. However, on buccal surfaces, 44.9% (U.S.A.), 30.5% (Norway) and 4.9% (Sri Lanka) of examined areas scored PlI=0. The lowest mean plaque scores for facial areas were found in the U.S.A., and highest scores were found in Sri Lanka. Distribution of PlI scores of 2 or 3 within the dentition of each group is shown in Table 5 and Figures 2 and 3. In all populations, the highest plaque scores for both mesial and buccal surfaces were found in molars. The lowest plaque scores in mesial surfaces were found on anterior teeth. In buccal sites, the lowest scores were observed in premolars, where less than 15% of surfaces demonstrated visible plaque in the U.S.A. and Norway.

In spite of great variation in oral hygiene levels between the subjects in the three groups, none demonstrated a completely plaque-free dentition. In fact, all participants had one or more surfaces with visible plaque (PlI= 2 or 3).

Calculus

Calculus index scores were expressed as means (Table 6) and frequency distributions (Table 7 and Figure 4) for each age cohort. In general, CI values increased with age in the three groups. The highest calculus scores were found on mesial surfaces. The percentage of mesial surfaces with CI scores greater than 0 were 39.7% at age 19-20 and 61.2% at age 29-30 in the U.S.A. For the same age groups in Norway, these values were 19.6% and 31.8%, respectively. In the 19-20 year old Sri Lankan cohort, 66.1% of mesial surfaces had calculus, and by age 27, 85.5% of mesial surfaces demonstrated calculus. In Sri Lanka, a similar increase of calculus scores with age was also found for buccal surfaces. This is contrary to Norway and the U.S.A., where only small changes in CI scores were found with increasing age on buccal surfaces.

Frequency of CI scores of 1 remained constant with age, while percentage of CI=2 increased with age. By 27-30 years, subgingival calculus was found on 13.9% (Norway), 34.5% (U.S.A.) and 68.1% (Sri Lanka) of examined surfaces. Figures 5,6,7 and 8 show percentage of mesial surfaces with subgingival calculus in anterior, premolar and molar areas by age cohort. In general, the highest levels of subgingival calculus were found in molar areas and lowest in anterior regions. The highest scores of subgingival calculus were found in Sri Lanka and, in general, the lowest scores were found in Norway for all tooth groups. However, in anterior regions, the U.S.A. and Norwegian groups had essentially the same low scores. In all populations, the percentage of surfaces with subgingival calculus increased with age for all tooth groups, and at age 27-28 in Sri Lanka, 91% of mandibular molars had subgingival calculus. In the 29-30 year old Americans, 56.6% of mandibular molars had subgingival calculus, and in Norway the corresponding value was 18.4%.

Scores of CI=3 were extremely rare in all three groups and were found in less than 0.01% of examined surfaces.

Caries and Fillings

Mean values and frequency distributions for CaI and FI are given in Tables 8 and 9. In the U.S.A., less than 10% of examined surfaces were given Fl scores of 1 or 2, and gingival caries was found on 1.1% of examined surfaces. In Sri Lanka, caries and fillings were rare and less than 1% of examined surfaces were given Fl or CaI scores of 1 or 2.

The Norwegian population had a generally high caries experience and 47.5% of interproximal areas and 10.1% of buccal areas had defective restorations. On mesial surfaces with defective fillings, 70% were found in a subgingival location in Norway. Frequency of filling scores greater than 0 varied from 0% in the mandibular anterior areas to essentially 100% in molar areas. Gingival caries occurred in approximately 3% of examined sites.

FI scores and CaI scores of 3 were virtually non-existent in all three groups.

Gingivitis

Mean gingival index scores and frequency distributions for each age cohort are shown in Tables 11 and 12, and Figure 9. Table 10 is a summary of values for all ages. Of all examined surfaces, 11.9% (Norway), 25.4% (U.S.A.) and 32.9% (Sri Lanka) scored Gl=2. A score of Gl=3 was rare in all three groups, and Gl scores of 0 occured in 17.1% (U.S.A.), 16.9% (Norway) and 10.6% (Sri Lanka) of all examined areas. In all groups, mesial surfaces consistently had the highest scores. The highest mean GI scores and the largest percentage of inflamed areas were found in Sri Lanka for both mesial and buccal areas. The Norwegian group had the lowest GI scores for mesial sites, while the U.S.A. population and the Norwegian population both demonstrated equally low scores for buccal areas.

Frequency distributions and mean values of GI scores changed little with age. On mesial surfaces, GI scores of 0 were rare, and 42.2% (U.S.A.), 42.1% (Sri Lanka) and 19.3% (Norway) of examined areas bled on probing. This is in contrast to buccal sites where 25.4% (U.S.A.), 18.0% (Norway) and 13.6% (Sri Lanka) scored Gl=0. Bleeding on probing was found in 23.6% of examined buccal areas in Sri Lanka and less than 10% of buccal sites in the U.S.A. and Norway.

Figures 10 and 11 show the distribution of GI scores of 2 by tooth groups. In all three populations the highest GI scores were found for molar areas on both mesial and buccal surfaces. The lowest GI scores on mesial surfaces were found in anterior regions, but for buccal areas the lowest scores were found in premolars. There was a tendency toward higher GI scores in the maxilla for molars and premolars than for their mandibular counterparts. In anterior regions, the highest scores were found in the mandible.

Loss of Attachment

Mean values and frequency distributions of Loss of Attachment (LA) scores by age cohort are presented in Tables 13 and 14 and Figure 12. Mesial LA scores were essentially the same in the three groups at age 19-20, when approximately 95% of examined surfaces measured 0-1 mm. In the 19-20 year olds, buccal surfaces had more loss of attachment than mesial surfaces. Mean loss of attachment on buccal surfaces were 0.47 ± 0.62 mm (U.S.A.), 0.43 ± 0.73 mm (Norway) and 0.34 ± 0.5 mm (Sri Lanka). In this age group, less than 1% of all surfaces had loss of attachment greater than 3 mm. However, 3-8% of all examined surfaces were given a LA score of 2 or 3 mm. A general slow increase in LA scores was found with age, and in the 27-29 year olds, mean attachment loss was 0.88 ± 0.95 mm (U.S.A.), 0.65 ± 0.77 mm (Norway), 0.71 ± 0.69 mm (Sri Lanka) for mesial surfaces and 1.30 ± 0.99 mm (U.S.A.), 0.98 ± 1.06 mm (Norway), and 1.08 ± 0.96 mm (Sri Lanka) for buccal surfaces. In the oldest age groups, LA scores greater than 3 mm were found in less than 2% of examined areas, and occurred primarily on buccal surfaces. Rates of attachment loss were low in all three groups, ranging from 0.03 mm/year on mesial surfaces in Norway to 0.1 mm/year on buccal surfaces in the U.S.A. In general, rates of attachment loss were lower in Norway than the U.S.A. or Sri Lanka.

Figures 13, 14 and 15 show mean loss of attachment scores for mesial and buccal surfaces in the youngest and oldest age groups for each population. In the 19-20 year old cohorts of all three groups, attachment loss was observed on essentially all tooth surfaces. Buccal surfaces had the highest LA scores, primarily involving the maxillary first molars and first bicuspids and the mandibular first bicuspids in all populations. On mesial surfaces, the 19-20 year old subjects in all groups showed highest LA scores on maxillary first molars. The oldest subjects in all three groups showed greater attachment loss on buccal surfaces than the 19-20 year olds. For mesial surfaces, most attachment loss was found on maxillary molars in the 27-30 year age group in all populations. However, in Norway and Sri Lanka, significant periodontal destruction was also observed in mandibular anterior areas. It is interesting to note that out of all mesial areas with attachment loss of 3 mm or more, 60% of these scores were found in maxillary molars in the U.S.A. and Norway, while in Sri Lanka no consistent pattern was found. Sixteen percent of subjects in the U.S.A. and 20% of subjects in Norway had LA scores of 3 mm or greater. In the majority of these subjects (94% in the U.S.A. and 70% in Norway) attachment loss was associated with the maxillary molars.

Gingival Recession

Table 15 and Figure 16 show mean values and frequency distributions of gingival recession scores for buccal surfaces in all age groups in the U.S.A.

The average gingival recession in 19-20 year old cohorts was 0.1 ± 0.32 mm and 90.6% of all buccal areas were given GR scores of 0 mm. Scores greater than 2 mm were not observed. Mean gingival recession increased in a nearly linear fashion with age. In the 29-30 year old group, the mean GR score was 0.58 ± 0.77 mm and 43.3% of buccal areas had gingival recession of 1 mm or greater. Only 2.1% of sites scored 3 mm or more.

Figure 17 shows mean values of loss of attachment and gingival recession for buccal surfaces by age cohort. A linear increase of loss of attachment, which was parallel to that for gingival recession, was found with increasing age.

Figure 18 shows the distribution of mean values of loss of attachment and gingival recession within the dentition at age 19-20 and 29-30. Gingival recession was observed in the youngest subjects primarily in premolars and first molars. This pattern was also observed in the oldest subjects. The distribution of gingival recession within the dentition paralleled scores for loss of attachment in all age groups.

Tooth Mortality

Tables 16 and 17 show mean number of remaining teeth and number of lost teeth by age groups. Minimal tooth loss was observed in all three populations. By age 19-20, all subjects had lost on an average of 0.5 tooth per person. From age 19-20 to 29-30 tooth mortality averaged 0.5 tooth in Norway and 1 tooth in U.S.A. and Sri Lanka.

As shown in Table 18 and Figure 19, few anterior teeth were lost in the three populations. In the U.S.A. and Norway, 62.3% and 50.4% of lost teeth were premolars, while in Sri Lanka 66.3% of teeth lost were molars.

Correlations

Table 19 shows correlation coefficients between values of PlI, CI, GI, LA, GR in the three populations. In all three, a significant correlation was observed between the presence of plaque and gingivitis, and between the presence of calculus and gingivitis. In the U.S.A. and Sri Lanka, a significant correlation was observed between gingival inflammation and loss of attachment. The latter relationship was not found in Norway. In the U.S.A., a strong correlation was seen between loss of attachment and gingival recession, while no significant correlation was observed between gingival inflammation and gingival recession.

Questionnaire

Seventy-one per cent of the U.S.A. subjects reported not smoking. The remainder of the population smoked daily. Seventy-four per cent of the U.S.A. subjects reported brushing at least 2 times per day, 22% once per day and 4% claimed brushing less than once a day. Frequency of interdental cleaning was far less common, and sixty-eight per cent of the U.S.A. subjects reported that they did not practice any kind of interdental cleaning.

Thirty-two per cent of the U.S.A. subjects reported visiting a dentist within the last 6 months. In the remainder of subjects, thirty-eight per cent had professional dental care in the last 1/2-1 year, and twenty per cent in the last 1-2 years. Ten per cent claimed that more than two years had passed since their last dental visit. Twenty-eight percent of the U.S.A. subjects reported previous orthodontic treatment.

DISCUSSION

Major differences were observed among the three populations with respect to retention indices and measures of periodontal disease. Of equal interest, however, were those findings common to the U.S.A., Norwegian and Sri Lankan groups.

With respect to plaque accumulation, all three populations showed substantially higher plaque scores in posterior than anterior areas. Plaque scores were highest in interdental sites and the least amount of plaque was found on buccal surfaces. This distribution within the dentition is in agreement with numerous other studies (Lövdal et al. 1958, Silness & Löe 1964, Lindhe & Koch 1966, Ainamo 1970, Alexander 1970, Cumming & Löe 1973, Lang et al. 1977, and Ånerud et al. 1979). The present data also agree with previous observations that maxillary incisors are the cleanest teeth of the dentition (Lightner et al. 1967). However, the U.S.A. and Norwegian populations demonstrated similarly low mean plaque values on maxillary premolars as on maxillary incisors. This may be related to brushing habits in these groups. It is interesting to note that the frequency of tooth brushing by these U.S. students is higher than what has previously been reported for the U.S.A. (Rovelstad 1959) and Norway (Kristoffersen 1970).

An asymmetrical distribution of plaque scores was observed between left and right sides of the dentition. In addition, variations were found both between individual teeth and between tooth surfaces. The trend toward lowest plaque scores on maxillary left regions may results from toothbrushing habits in which right handed persons directed more attention toward maxillary left than maxillary right areas. No information is available on cleaning habits in the Sri Lankan population. However, this group demonstrated significantly lower plaque scores on the buccal than on interproximal surfaces. This indicates that the oral hygiene practices of these subjects differ from what has been reported for Sri Lanken tea plantation workers where essentially no difference was found in plaque index scores between mesial and buccal surfaces (Ånerud et al. 1979).

Similar to Sri Lankan subjects, the U.S.A. and Norway groups showed more plaque on interdental than buccal areas. Of total mesial surfaces examined, 50% (Norway), 64% (U.S.A.) and 90% (Sri Lanka) demonstrated visible plaque. Thus, all three populations must be characterized as poor interdental cleaners, while in buccal regions, the U.S.A. and Norwegian groups practiced good oral hygiene.

The finding in all populations that dental calculus accumulated most frequently in lower incisor and maxillary molar areas is in agreement with previous reports (Black 1913, Lövdal et al. 1958, Silness & Löe 1964, Lightner et al. 1967, Sznajder et al. 1968, Löe et al. 1978a). Calculus was more often observed on mesial surfaces than buccal surfaces, which is also consistent with earlier studies (Lövdal et al. 1958, Silness & Löe 1964). Little previous information is available on the distribution of calculus within the dentition as determined by the Retention Index system. In this study, the highest scores were found on mesial surfaces of lower central incisors and the lowest scores on maxillary central incisors. In general higher CI values were seen in the mandible than maxilla. This distribution was also found when supragingival calculus and subgingival calculus scores were separated, and agrees with previous studies employing other methods for calculus assessment (Lövdal et al. 1958).

The lowest calculus scores were found in Norway which probably reflects the documented high frequency of dental visits in this group (Ramm 1952, Ramm 1954, Hansen 1976). The higher calculus scores in the U.S.A. and Sri Lanka, where 1/3 (U.S.A.) and 2/3 (Sri Lanka) of interproximal surfaces demonstrated subgingival calculus at age 27-30, is possibly a result of poor interdental oral hygiene combined with inadequate interproximal professional calculus removal.

The high exposure of the Norwegian population to dental services was also reflected by high Filling Margin scores compared with the other groups. This is in agreement with studies which reported higher DMF-S scores in Scandinavian countries compared to other countries in Europe and North America (Miller 1943, Starkey 1962, Massler et al. 1952, Rovelstad et al. 1959, Scheinin et al. 1969, Marken & Rosenberg 1964, Mjör 1958). The highest Filling Margin scores were found on mesial surfaces and lowest scores were recorded on buccal surfaces, which is in agreement with results of Backer Dirks (1961) showing that caries occurs most frequently on occlusal and interproximal surfaces and least frequently on buccal and lingual surfaces. The finding that approximately 50% of total examined interproximal surfaces and 10% of buccal surfaces demonstrated imperfect filling margins in Norway may seem very high. However, the scoring system employed in the present study is very sensitive. The high value for interproximal surfaces indicates that most fillings are not perfect according to this index. This is in agreement with the findings of Bjørn, Bjørn and Grkovic (1969), Arneberg, Silness and Nordbø (1980). Ainamo (1970) reported a strong association between FI scores and scores of filled surfaces according to the DMF-S scoring system of Klein (1938). Mean FI values in the Norwegian group were higher than what has been previously been reported in Finish soldiers (Ainamo 1970). However, this latter group had higher scores than what was found in the U.S.A. and Sri Lanka. The low FI scores in Sri Lanka makes it difficult to determine distribution of filling scores. In the U.S.A. and Norway, the highest FI scores occurred in molars and the lowest scores in mandibular incisors and canines. This is in agreement with an earlier report (Ainamo 1970). The low frequency of carious lesions in the gingival area in all three populations suggests that untreated caries is a relatively small problem.

Mean Gingival Index scores in the U.S., Norwegian and Sri Lankan students were lower than in Finish soldiers (Ainamo 1970), and at or above levels reported for first year Danish dental students (Lang et al. 1977), Finish students (Scheinin et al. 1970) and young French adults (Cahen et al. 1977). Of the total surfaces examined, 12% in Norway, 25% in the U.S.A. and 33% in Sri Lanka demonstrated bleeding on probing. This is in contrast to findings in Sri Lankan tea plantation workers, where approximately 90% of examined sites demonstrated bleeding on probing (Ånerud et al. 1979). Buccal surfaces showed lower GI scores than mesial surfaces in all groups. Highest mean Gingival Index scores were found in Sri Lanka for both buccal and mesial sites. However, the U.S.A. population scored only slightly lower values in interproximal areas. In buccal areas the Norwegian and U.S.A. groups were alike both with respect to mean values and frequency distribution of GI scores. In spite of differences in prevalence and severity of gingival inflammation in the three populations, the intraoral distribution was similar. Highest GI scores were found on mesial surfaces of maxillary posterior teeth and lowest on buccal surfaces of maxillary anterior teeth. This distribution is in agreement with some authors (Marshall-Day et al. 1955, Parfitt 1959). However, others have reported higher GI values in mandibular molars than for maxillary molars (Lindhe & Koch 1966, Koch & Lindhe 1967).

The finding that the Norwegian group had the lowest Gingival Index scores and the highest percentage of tooth surfaces with defective fillings is interesting. Several authors have suggested that the presence of dental restorations have an adverse effect on gingival health (Karlsen 1970, Silness 1970) and may contribute to periodontitis (Björn et al. 1969, Björn, Björn & Grkovic 1970, Valderhaug & Birkeland 1976 and Valderhaug 1980). However, Waerhaug (1975) demonstrated the presence of plaque on subgingival restorations and suggested that gingival inflammation was caused by the bacterial plaque rather than defective filling margins or rough surfaces (Waerhaug 1956). Thus it may be possible to maintain gingival health in the presence of dental restorations which do not prevent adequate oral hygiene. The Norwegian group demonstrated lowest plaque and calculus scores and was able to maintain good oral hygiene in spite of presence of plaque retentive fillings.

Most of the examined subjects in all the groups demonstrated one or more sites with loss of attachment. This is higher than previously reported for U.S. Air Force cadets (Lightner et al. 1967), Finish soldiers (Ainamo 1970), and young adults (Sheiham 1969) and soldiers (Milne 1967) in England. In general, however, mean LA values observed in the present study were low, and agreed with a previous U.S. study on a comparable age group (Suomi & Doyle 1972). No cases of juvenile periodontitis were observed in any of the young adult groups. This is consistent with previous studies in Sri Lanka (Waerhaug 1967) and the United States (Kaslick & Chasens 1968, Lacy & Basher 1977). Studies reporting on the intraoral distribution of periodontal destruction have previously found more bone loss in interproximal than buccal areas (Lövdal et al. 1958) and a tendency toward more bone loss on the right than the left sides of both jaws (Schei et al. 1959). In all three populations of this study, loss of attachment was most frequent and severe on buccal surfaces. It is tempting to relate this to faulty brushing habits, a suggestion which is further supported by the high prevalence of gingival recession in the U.S.A., where recession was primarily found on buccal surfaces with lowest PlI scores. This is in agreement with previous studies where recession has been related to good oral hygiene (Kitchin 1941, Gorman 1967, O'Leary et al. 1968, 1971, Sangnes & Gjermo 1976). The relationship of faulty tooth-brushing to gingival recession and loss of the periodontal supporting tissues needs further study to determine the relative importance of mechanical tooth cleaning as a possible etiological factor.

The prevalence of gingival recession found in the U.S.A. is higher than previously reported by some authors (Kitchin 1941, O'Leary et al. 1968, 1971) while similar to other reports (Ervin & Bucher 1944, Sangnes & Gjermo 1976). The distribution of recession is less clear. In the present study, recession was greatest on maxillary first premolars and molars, and mandibular first premolars which is in agreement with the distribution of alveolar dehiscences described by Larato (1970). Other studies have found recession primarily in mandibular central incisor areas (Moskow & Bressman 1965, Miglani 1973). Some authors have observed recession most frequently on maxillary cuspids (Gorman 1967) and on buccal surfaces of first premolars (Gorman 1967, Sangnes & Gjermo 1976) while others have found recession most often in posterior segments (O'Leary et al. 1968). In spite of these discrepancies, the majority of reports indicate that gingival recession is found primarily in maxillary posterior areas. Recession was found to increase in frequency and severity with age. In the present study, 12% of examined surfaces scored greater than 0. Further study is necessary to evaluate its clinical importance.

When evaluating the data from these three student populations, it must be kept in mind that all subjects were selected because of accessibility and willingness to participate. In addition, the examinations in the United States were completed 9 to 13 years later than the examinations in Norway and Sri Lanka. This appears not to be a major problem since recent surveys of the Norwegian group indicates that no significant changes in oral hygiene or periodontal condition have occurred.

SUMMARY

The purpose of the present study was to assess periodontal destruction and related etiological factors in three young adult male populations in the U.S.A., Norway and Sri Lanka. The clinical examination included the Plaque Index (Silness & Löe 1964), Retention Index for calculus, defective fillings and gingival caries (Löe 1967), Gingival Index (Löe & Silness 1963), Loss of Attachment (Ramfjord 1959) and Gingival Recession. 1959).

The Sri Lankan group had the highest scores for plaque, calculus, and gingivitis on both mesial and buccal surfaces of the teeth. The U.S.A. group demonstrated high levels of plaque, calculus, and gingivitis in interdental areas. On buccal surfaces, the U.S.A. and Norwegian groups demonstrated equally low scores of soft and hard bacterial deposits and gingival inflammation. The filling experience was high in Norway compared to the U.S.A. and Sri Lankan groups where few defective fillings were found. Caries related to the gingival margin was rare in all three groups.

In general, mean loss of attachment was low in the three groups. Rates of attachment loss ranged from 0.03 mm/year to 0.1 mm/year. Buccal surfaces had greater loss of attachment in all age cohorts in all groups. In the U.S.A. group, loss of attachment was paralleled by recession. Tooth mortality was low in the three groups.

CONCLUSIONS

1. Interdental cleaning was inadequate in all three populations. Personal oral hygiene was effective on buccal surfaces in the U.S.A. and Norway, but not in Sri Lanka.

2. Professional removal of calculus was incomplete in both buccal and interproximal surfaces in the Sri Lankan group. This was also true in interproximal surfaces in the U.S.A. group.

3. Despite major geographical, racial and previous dental care differences, measurements of loss of attachment suggest that periodontitis has not caused significant degredation of periodontal supporting structures in the age groups of all three populations. The potential for such loss of periodontal support appears to be high in interdental areas of subjects in the U.S.A. and both buccal and interproximal surfaces in Sri Lanka.

FUTURE STUDIES

The present study suggested that the presence of suspected etiological factors held a high potential for loss of periodontal attachment in interproximal areas of subjects in the U.S.A., and Sri Lanka. Testing of this hypothesis would require longitudinal studies of these groups or similar populations.

Subjects in this investigation were selected partly because of their accessibility and willingness to participate in the examinations. In addition, these University students probably represented the higher socio-economic strata in each country. Such is clearly true in Sri Lanka where the periodontal status of tea laborers (Löe et al. 1978a,b,c) was substantially worse than the University students reported here. Thus, future studies must also be directed to subjects representative of the general population.

Finally, statistical analysis of the interrelationships among exogenous factors and measures of periodontal disease in subjects within each group and between the groups was beyond the specific objectives of the present report. However, all data has been stored in computer files, the format of which will allow such analysis in the future.

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TABLE 1

AGE	USA	NORWAY	SRI LANKA
19-20	16	57	16
21-22	20	75	72
23-24	24	84	51
25-26	20	90	27
27-28	18	25	13
29-30	15	39	03
TOTAL	113	370	182

Number of participants by 2 year age cohort.

TABLE 2

PLAQUE INDEX

		MESIAL			BUCCAL		
AGE		N	Mean	SD	N	Mean	SD
19-20							
	USA	438	1.60	0.62	438	0.87	0.82
	NOR	1560	1.45	0.52	1560	0.90	0.73
	SRI	440	1.93	0.26	440	1.51	0.56
21-22							
	USA	539	1.63	0.54	539	0.81	0.79
	NOR	2059	1.48	0.52	2059	0.93	0.74
	SRI	1969	1.87	0.35	1971	1.40	0.59
23-24							
	USA	655	1.56	0.59	655	0.73	0.74
	NOR	2292	1.49	0.52	2292	0.87	0.70
	SRI	1384	1.95	0.26	1385	1.45	0.63
25-26							
	USA	549	1.62	0.63	549	0.73	0.77
	NOR	2442	1.52	0.51	2442	0.90	0.67
	SRI	703	1.96	0.26	705	1.63	0.56
27-28							
	USA	491	1.43	0.74	491	0.59	0.74
	NOR	687	1.60	0.51	687	0.98	0.66
	SRI	345	1.95	0.25	345	1.62	0.54
29-30							
	USA	394	1.74	0.51	394	0.78	0.77
	NOR	1050	1.46	0.54	1050	0.80	0.69
	SRI		*			*	

Plaque Index scores, mean values and 1 standard deviation (SD) for mesial and buccal surfaces.
* = values were not calculated.

TABLE 3

PLAQUE INDEX

AGE		MESIAL 0	MESIAL 1	MESIAL 2	MESIAL 3	BUCCAL 0	BUCCAL 1	BUCCAL 2	BUCCAL 3
19-20									
	USA	6.8	26.3	66.7	0.2	39.0	37.0	22.1	1.8
	NOR	0.8	53.1	45.7	0.2	31.6	47.1	21.1	0.3
	SRI	0.0	7.3	92.7	0.0	3.0	43.6	53.2	0.2
21-22									
	USA	3.2	30.8	66.0	0.0	41.6	37.1	20.4	0.9
	NOR	0.9	50.3	48.6	0.2	31.0	45.5	23.1	0.4
	SRI	0.6	11.7	87.5	0.3	4.8	50.7	44.1	0.4
23-24									
	USA	5.0	34.4	60.3	0.3	44.1	38.6	17.1	0.7
	NOR	0.8	49.2	49.8	0.2	31.8	49.7	18.5	0.1
	SRI	0.0	5.7	93.1	1.2	6.9	42.0	50.5	0.6
25-26									
	USA	6.6	26.4	65.6	1.5	45.9	36.2	17.1	0.7
	NOR	0.5	47.1	52.3	0.2	28.1	54.2	17.4	0.2
	SRI	0.0	5.4	93.3	1.3	3.7	29.8	66.0	0.6
27-28									
	USA	15.1	27.3	57.6	0.0	56.6	28.1	15.3	0.0
	NOR	0.9	38.6	60.6	0.0	22.1	57.8	19.8	0.3
	SRI	0.0	5.8	93.3	0.9	2.0	35.1	62.0	0.9
29-30									
	USA	2.8	21.1	75.6	0.5	41.4	40.9	16.0	1.8
	NOR	2.3	49.0	48.7	0.0	35.9	48.3	15.8	0.0
	SRI			*				*	

Percentage frequency distribution of Plaque Index scores 0,1,2,3 on mesial and buccal surfaces.
* = values were not calculated.

TABLE 4

PLAQUE INDEX

		N	MEAN	SD	PERCENT OF SCORES 0	1	2	3
USA								
	M	3066	1.59	0.62	6.6	28.3	64.7	0.4
	B	3066	0.75	0.77	44.9	36.3	18.0	0.8
NOR								
	M	10090	1.50	0.52	0.9	48.8	50.1	0.2
	B	10090	0.89	0.70	30.5	44.9	19.4	0.2
SRI								
	M	4916	1.92	0.30	0.2	8.1	91.0	0.7
	B	4921	1.48	0.60	4.9	43.2	51.4	0.5

Mean values, 1 standard deviation (SD) and frequency distribution of Plaque Index scores on mesial (M) and buccal (B) surfaces in all age groups.

TABLE 5

PLAQUE INDEX

	MAXILLA					
	MESIAL			BUCCAL		
	MOL	PRE	ANT	MOL	PRE	ANT
USA	87.5	60.1	51.6	40.0	7.1	10.8
NORWAY	69.0	46.8	38.1	34.2	11.1	18.4
SRI LANKA	96.4	92.5	88.7	65.4	43.5	51.4
	MANDIBLE					
USA	74.2	58.1	66.1	22.8	9.6	23.2
NORWAY	77.0	58.0	30.3	27.9	16.0	13.6
SRI LANKA	94.1	92.0	89.3	59.8	37.9	53.7

Percentage of total surfaces with PLI=2 or 3 by
tooth group for mesial and buccal surfaces.
MOL=Molars, PRE=Premolars, ANT=Anterior

TABLE 6

CALCULUS INDEX

AGE		MESIAL n	MESIAL Mean	MESIAL SD	BUCCAL n	BUCCAL Mean	BUCCAL SD
19-20							
	USA	438	0.49	0.67	438	0.12	0.36
	NOR	1560	0.23	0.51	1560	0.05	0.23
	SRI	440	1.18	0.91	440	0.57	0.79
21-22							
	USA	539	0.52	0.67	539	0.13	0.36
	NOR	2036	0.29	0.58	2063	0.08	0.30
	SRI	1969	1.22	0.92	1971	0.59	0.85
23-24							
	USA	655	0.51	0.72	655	0.10	0.36
	NOR	2295	0.34	0.63	2295	0.07	0.27
	SRI	1384	1.38	0.83	1385	0.65	0.87
25-26							
	USA	549	0.68	0.79	549	0.11	0.34
	NOR	2443	0.41	0.69	2443	0.07	0.30
	SRI	703	1.50	0.78	705	0.80	0.89
27-28							
	USA	491	0.73	0.83	491	0.14	0.40
	NOR	688	0.44	0.73	688	0.07	0.29
	SRI	345	1.54	0.73	345	0.93	0.91
29-30							
	USA	394	0.96	0.86	394	0.27	0.61
	NOR	1053	0.46	0.73	1053	0.06	0.27
	SRI		*			*	
All							
	USA	3066	0.63	0.77	3066	0.14	0.41
	NOR	10090	0.36	0.65	10090	0.07	0.28
	SRI	4916	1.32	0.87	4921	0.66	0.86

Calculus Index, mean values and 1 standard deviation (SD) for scores on mesial and buccal surfaces.
* = values were not calculated.

TABLE 7

CALCULUS INDEX

AGE		MESIAL 0	MESIAL 1	MESIAL 2	MESIAL 3	BUCCAL 0	BUCCAL 1	BUCCAL 2	BUCCAL 3
19-20									
	USA	60.3	30.1	9.6	0.0	89.3	9.6	1.1	0.0
	NOR	80.4	15.7	3.8	0.0	95.4	4.4	0.3	0.0
	SRI	33.9	13.9	52.3	0.0	61.8	19.3	18.9	0.0
21-22									
	USA	58.1	31.9	10.0	0.0	87.6	11.7	0.7	0.0
	NOR	77.2	16.7	5.8	0.3	93.0	6.1	0.9	0.0
	SRI	32.8	13.6	52.8	0.9	64.6	12.4	22.5	0.5
23-24									
	USA	62.6	24.0	13.4	0.0	91.8	6.4	1.8	0.0
	NOR	74.9	16.3	8.8	0.0	93.8	5.8	0.4	0.0
	SRI	22.2	17.9	59.5	0.4	61.2	13.1	25.6	0.1
25-26									
	USA	52.5	27.5	20.0	0.0	89.6	9.5	0.9	0.0
	NOR	71.0	17.4	11.5	0.0	93.5	5.6	0.9	0.0
	SRI	17.8	14.4	67.1	0.1	51.6	17.3	30.9	0.1
27-28									
	USA	51.5	24.0	24.4	0.0	88.2	9.8	2.0	0.0
	NOR	70.2	15.4	14.4	0.0	93.9	5.2	0.9	0.0
	SRI	14.5	17.4	68.1	0.0	45.2	16.2	38.6	0.0
29-30									
	USA	38.8	26.6	34.5	0.0	81.5	9.9	8.6	0.0
	NOR	68.2	17.9	13.9	0.0	95.4	3.6	0.9	0.0
	SRI		*				*		
All									
	USA	54.8	27.2	17.9	0.0	88.4	9.3	2.3	0.0
	NOR	73.4	17.0	9.5	0.1	93.9	5.4	0.7	0.0
	SRI	26.5	15.1	57.9	0.5	60.0	14.3	25.4	0.2

Calculus Index, percentage frequency distribution of CI scores 0,1,2,3 .

TABLE 8

FILLING MARGIN INDEX

		N	MEAN	SD	PERCENT OF SCORES 0	1	2	3
USA								
	M	3066	0.14	0.48	91.2	3.5	5.3	0.0
	B	3066	0.04	0.24	97.1	1.9	1.0	0.0
NOR								
	M	10090	0.81	0.91	52.5	14.1	33.3	0.3
	B	10090	0.12	0.40	89.9	7.8	2.1	0.1
SRI								
	M	4920	0.01	0.10	99.7	0.1	0.2	0.0
	B	4920	0.00	0.02	99.9	0.1	0.0	0.0

Filling Margin Index, mean values, 1 standard deviation (SD) and percentage frequency distribution of FI scores 0,1,2,3 on mesial (M) and buccal (B) surfaces.

TABLE 9

GINGIVAL CARIES INDEX

		N	MEAN	SD	PERCENT OF SCORES 0	1	2	3
USA								
	M	3066	0.02	0.14	98.4	1.5	0.1	0.0
	B	3066	0.01	0.10	99.4	0.5	0.1	0.0
NOR								
	M	10089	0.04	0.22	96.7	2.8	0.5	0.0
	B	10089	0.03	0.19	97.2	2.5	0.3	0.0
SRI								
	M	4927	0.01	0.09	99.6	0.2	0.2	0.0
	B	4927	0.00	0.02	100.0	0.0	0.0	0.0

Gingival Caries Index, mean values, 1 standard deviation (SD) and frequency distribution of CaI scores 0,1,2,3 on mesial (M) and buccal (B) surfaces.

TABLE 10

GINGIVAL INDEX

		N	MEAN	SD	PERCENT OF SCORES 0	1	2	3
USA								
	M	3067	1.33	0.63	8.8	49.0	42.2	0.0
	B	3067	0.83	0.56	25.4	66.0	8.6	0.0
NOR								
	M	10090	1.04	0.59	15.7	65.0	19.3	0.1
	B	10090	0.87	0.56	18.0	77.3	4.6	0.0
SRI								
	M	4920	1.36	0.62	7.4	50.1	42.1	0.4
	B	4920	1.10	0.61	13.6	62.6	23.6	0.2

Mean values, 1 standard deviation (SD) and frequency distribution of Gingival Index scores on mesial (M) and buccal (B) surfaces in all age groups.

TABLE 11

GINGIVAL INDEX

AGE		MESIAL N	MESIAL MEAN	MESIAL SD	BUCCAL N	BUCCAL MEAN	BUCCAL SD
19-20							
	USA	438	1.24	0.56	438	0.80	0.53
	NOR	1560	0.98	0.64	1560	0.84	0.47
	SRI	440	1.35	0.60	440	1.10	0.52
21-22							
	USA	539	1.40	0.63	539	0.85	0.55
	NOR	2059	1.02	0.64	2059	0.86	0.47
	SRI	1971	1.31	0.63	1971	1.09	0.57
23-24							
	USA	655	1.32	0.64	655	0.77	0.59
	NOR	2292	1.05	0.57	2292	0.87	0.44
	SRI	1386	1.35	0.62	1386	1.04	0.65
25-26							
	USA	550	1.33	0.65	550	0.81	0.57
	NOR	2442	1.09	0.60	2442	0.88	0.48
	SRI	704	1.50	0.60	704	1.21	0.66
27-28							
	USA	491	1.29	0.65	491	0.84	0.50
	NOR	687	1.05	0.53	687	0.88	0.43
	SRI	344	1.34	0.62	344	1.17	0.60
29-30							
	USA	394	1.44	0.64	394	0.98	0.58
	NOR	1050	1.01	0.48	1050	0.86	0.43
	SRI		*			*	

Gingival Index, mean values and 1 standard deviation (SD).
* = values were not calculated.

TABLE 12

GINGIVAL INDEX

AGE		MESIAL 0	MESIAL 1	MESIAL 2	MESIAL 3	BUCCAL 0	BUCCAL 1	BUCCAL 2	BUCCAL 3
19-20									
	USA	6.4	63.2	30.4	0.0	26.5	67.4	6.4	0.0
	NOR	21.0	59.6	19.4	0.0	20.5	75.1	4.4	0.0
	SRI	5.2	55.5	38.0	1.3	8.9	72.0	19.1	0.0
21-22									
	USA	7.8	44.9	47.3	0.0	23.6	68.1	8.2	0.1
	NOR	19.6	59.3	21.1	0.0	18.7	76.2	5.1	0.0
	SRI	8.1	53.2	38.0	0.7	12.0	67.6	20.0	0.4
23-24									
	USA	9.3	49.5	41.2	0.0	31.5	60.2	8.3	0.0
	NOR	13.8	67.5	18.7	0.0	16.8	79.2	4.0	0.0
	SRI	8.2	49.1	42.7	0.0	18.8	58.0	23.2	0.0
25-26									
	USA	10.0	47.1	42.9	0.0	27.6	63.6	8.8	0.0
	NOR	13.9	67.3	22.1	0.2	17.9	76.1	5.9	0.0
	SRI	5.3	39.9	54.8	0.0	13.5	51.6	34.9	0.0
27-28									
	USA	11.0	49.1	39.9	0.0	22.0	72.1	5.9	0.0
	NOR	11.9	71.3	16.7	0.0	16.3	79.8	3.9	0.0
	SRI		*				*		

Gingival Index, percentage frequency distribution of scores 0,1,2,3 by age.
* = values were not calculated.

TABLE 13

LOSS OF ATTACHMENT

AGE		USA			NORWAY			SRI LANKA		
		N	Mean	SD	N	Mean	SD	N	Mean	SD
19-20										
	M	438	0.29	0.51	1530	0.33	0.63	439	0.31	0.53
	B	438	0.47	0.62	1541	0.43	0.73	440	0.34	0.65
21-22										
	M	539	0.40	0.63	2031	0.39	0.67	1956	0.30	0.56
	B	539	0.69	0.83	2039	0.56	0.88	1968	0.39	0.66
23-24										
	M	650	0.51	0.78	2242	0.54	0.72	1376	0.44	0.66
	B	649	0.75	0.83	2256	0.78	0.92	1386	0.62	0.82
25-26										
	M	546	0.64	0.80	2336	0.57	0.81	692	0.69	1.01
	B	545	1.00	0.95	2362	0.80	1.06	703	0.93	1.16
27-28										
	M	480	0.86	0.87	660	0.44	0.66	343	0.71	0.69
	B	480	1.16	1.00	667	0.77	1.05	344	1.08	0.96
29-30										
	M	393	0.88	0.95	1019	0.65	0.77		*	
	B	393	1.30	0.99	1017	0.98	1.06		*	

Loss of Attachment, mean values and 1 standard deviation (SD) of scores in mm.
* = values were not calculated.

TABLE 14

LOSS OF ATTACHMENT

AGE		0-1	2-3	4-5	>5	0-1	2-3	4-5	>5
19-20									
	USA	97.0	3.0	0.0	0.0	93.6	6.4	0.0	0.0
	NOR	94.0	5.6	0.4	0.0	91.7	7.9	0.4	0.0
	SRI	95.5	3.5	0.0	0.0	94.1	5.9	0.0	0.0
21-22									
	USA	92.2	7.8	0.0	0.0	84.1	15.6	0.4	0.0
	NOR	94.6	4.8	0.4	0.0	89.0	9.5	1.4	0.1
	SRI	97.5	2.3	0.2	0.0	93.8	5.8	0.4	0.0
23-24									
	USA	85.8	14.2	0.0	0.0	82.6	16.8	0.6	0.0
	NOR	91.2	8.4	0.4	0.0	82.4	16.2	1.4	0.0
	SRI	95.7	3.7	0.5	0.1	88.1	11.2	0.6	0.0
25-26									
	USA	82.6	17.4	0.0	0.0	71.2	27.7	1.1	0.0
	NOR	88.3	10.9	0.8	0.0	81.7	15.5	2.5	0.4
	SRI	87.5	9.8	1.7	0.9	78.4	17.6	3.4	0.6
27-28									
	USA	72.3	27.5	0.2	0.0	66.4	31.7	1.7	0.2
	NOR	93.8	6.1	0.0	0.2	83.8	13.7	1.7	0.6
	SRI	92.2	7.6	0.2	0.0	76.4	21.2	2.3	0.0
29-30									
	USA	76.9	22.4	0.8	0.0	58.5	40.0	1.5	0.0
	NOR	88.6	11.0	0.5	0.0	74.4	23.4	2.0	0.2
	SRI		*				*		

Loss of Attachment, percentage frequency distribution of scores 0-1, 2-3, 4-5 and >5 mm by age in USA, Norway (NOR) and Sri Lanka (SRI).

TABLE 15

GINGIVAL RECESSION

AGE	% ind	N	Mean	SD	0mm	1-2mm	3-4mm	>4mm
19-20	56.3	438	0.10	0.32	90.6	9.4	0.0	0.0
21-22	60.0	539	0.17	0.48	86.6	13.0	2.8	0.2
23-24	83.3	651	0.23	0.52	81.0	18.6	0.5	0.0
25-26	80.0	546	0.38	0.67	70.1	29.3	0.4	0.2
27-28	77.7	481	0.42	0.76	70.5	27.3	2.1	0.2
29-30	100.0	393	0.58	0.77	56.7	41.2	2.1	0.0

Percentage of examined individuals with gingival recession (% ind), mean scores, 1 standard deviation (SD) and percentage of buccal surfaces with gigival recession 0,1-2, 3-4 and >4 mm in the U.S.A.

TABLE 16

REMAINING TEETH

AGE	USA	NORWAY	SRI LANKA
19-20	27.4	27.4	27.5
21-22	26.9	27.4	27.4
23-24	27.3	27.3	27.2
25-26	27.4	27.1	26.1
27-28	27.3	27.5	26.5
29-30	26.3	26.9	25.0

Mean number of remaining teeth.

TABLE 17

TOOTH MORTALITY

AGE		USA Mol	USA Pre	USA Ant	Norway Mol	Norway Pre	Norway Ant	Sri Lanka Mol	Sri Lanka Pre	Sri Lanka Ant
19-20										
	Max	0	4	0	2	20	0	1	0	0
	Mnd	0	6	0	7	3	4	7	0	0
21-22										
	Max	1	9	1	7	16	2	12	4	3
	Mnd	2	7	1	8	7	1	22	2	2
23-24										
	Max	2	5	1	6	17	9	8	3	5
	Mnd	4	5	0	14	14	0	19	3	4
25-26										
	Max	1	5	0	16	23	5	9	8	5
	Mnd	1	4	0	12	15	7	23	5	2
27-28										
	Max	5	2	2	0	6	2	5	5	0
	Mnd	4	0	0	4	1	0	7	1	1
29-30										
	Max	3	8	1	10	6	5	1	2	0
	Mnd	7	6	1	12	8	1	2	4	0

Total number of teeth lost by tooth group in maxilla (max) and mandible (Mnd).
Mol = Molar, Pre = Premolars, Ant = Anteriors.

TABLE 18

TOOTH MORTALITY

	Molars		Pre-Molars		Anteriors	
	N	%	N	%	N	%
USA						
Maxilla	12	12.2	33	33.7	5	5.1
Mandible	18	18.4	28	28.6	2	2.0
Total	30	30.6	61	62.3	7	7.1
NORWAY						
Maxilla	41	15.2	88	32.6	23	8.5
Mandible	57	21.1	48	17.8	13	4.8
Total	98	36.3	136	50.4	36	13.3
SRI LANKA						
Maxilla	36	20.6	22	12.6	13	7.4
Mandible	80	45.7	15	8.6	9	5.1
Total	116	66.3	37	21.2	22	12.5

Number (N) and percentage of teeth lost by tooth group.

TABLE 19

CORRELATION COEFFICIENTS

USA

	PlI	CI	GI	LA
PlI	-			
CI	0.4763	-		
GI	0.5870	0.5928	-	
LA	0.2784	0.5463	0.4463	-
GR	0.0507	0.2787	0.1749	0.7776

NORWAY

	PlI	CI	GI	LA
PlI	-			
CI	0.2682	-		
GI	0.3641	0.3838	-	
LA	0.0361	0.2109	0.1071	-

SRI LANKA

	PlI	CI	GI	LA
PlI	-			
CI	0.7306	-		
GI	0.5422	0.6810	-	
LA	0.2972	0.4479	0.4314	-

Correlation coefficients between values of Plaque Index (PlI), Calculus Index (CI), Gingival Index (GI), Loss of Attachment (LA) and Gingival Recession (GR) scores based on linear regression analysis for all values given on mesial and buccal surfaces.

TABLE 20

INTER EXAMINER AGREEMENT

	N	All	Mol	Pre	Ant
PlI	580	73.7	75.0	74.4	71.2
CI	442	85.7	84.7	85.5	87.5
FI	388	94.1	95.6	92.0	90.4
CaI	416	98.9	97.8	97.3	100.0
GI	403	73.4	78.6	67.2	74.3
LA	451	70.5	69.3	68.2	73.3

Inter examiner agreement based on scoring of Plaque Index (PlI), Calculus Index (CI), Marginal Filling Index (FI) Gingival Caries Index (CaI), Gingival Index (GI) and Loss of Attachment on randomly selected surfaces in 14 subjects. Values represent percentage of surfaces where both examiners agreed.

TABLE 21

INTRA EXAMINER REPRODUCIBILITY

	N	All	Mol	Pre	Ant
PlI	280	79.1	78.4	79.5	79.8
CI	280	91.8	89.8	94.3	91.3
FI	280	97.9	97.7	97.7	100.0
CaI	280	100.0	100.0	100.0	100.0
GI	280	76.4	74.0	76.1	79.5
LA	272	80.5	80.9	73.8	85.6
GR	68	91.0	90.4	95.2	88.0

Intra examiner reproducibility for all teeth (All), molars (Mol), pre-molars (Pre) and anteriors (Ant). Values represent percentage of scores in perfect agreement for Plaque Index (PlI), Calculus (CI), Margin Filling Index (FI), Gingival Caries Index (CaI), Gingival Index (GI), Loss of Attachment (LA) and Gingival Recession on selected surfaces in 8 subjects at first and second scoring.

TABLE 22

AGREEMENT MATRIX

LOSS OF ATTACHMENT

		Examiner 1				
		0	1	2	3	>3
Examiner 2	0	143	25	7	0	0
	1	36	151	19	0	0
	2	5	28	18	3	0
	3	0	2	5	6	1
	>3	0	0	0	0	0

Agreement matrix for Loss of Attachment for 449 scores in 14 individuals. Perfect agreement was reached in 70.5 of scored areas. Agreement within +- 1mm was found in 96.6% of scored areas.

TABLE 23

REPRODUCIBILITY MATRIX

LOSS OF ATTACHMENT

		First Exam				
		0	1	2	3	>3
Second Exam	0	134	14	2	0	0
	1	16	58	7	0	0
	2	0	6	24	2	0
	3	0	1	2	3	1
	>3	0	0	0	0	0

Reproducibility of 270 scores of Loss of Attachment in 8 subjects. Perfect agreement was found in 80.5% of examined areas. Agreement +- 1mm was found in 97.8% of examined areas.

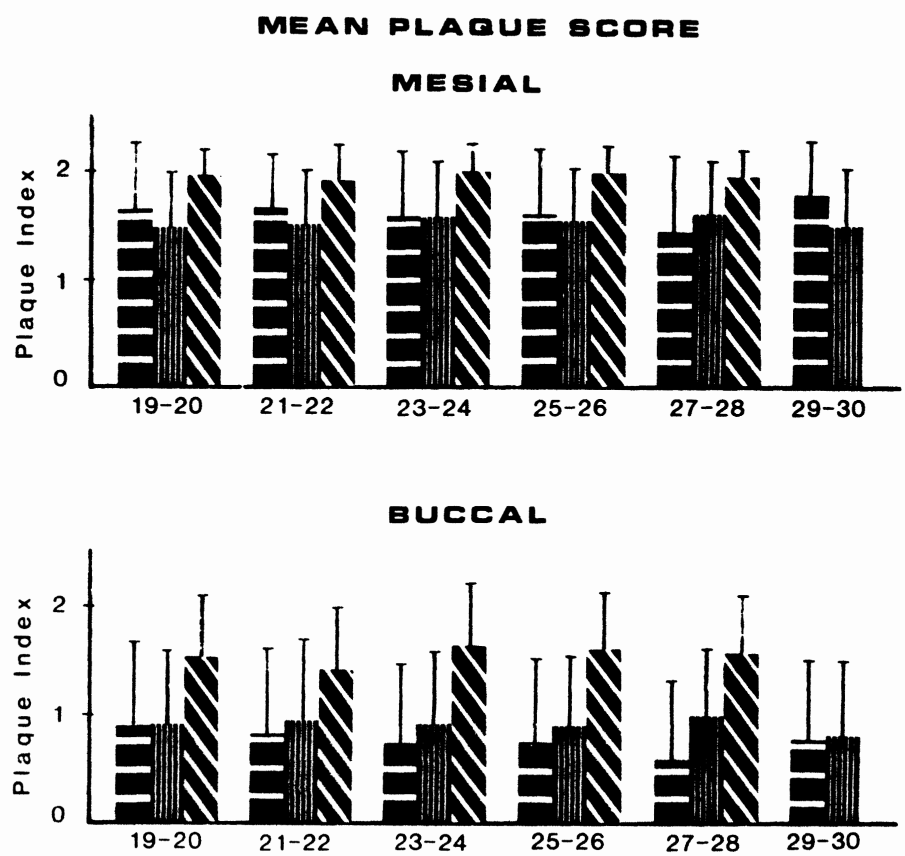

Figure 1.

Mean Plaque Index scores and standard deviations by age group in the U.S.A. ( ), Norway ( ) and Sri Lanka ( ).

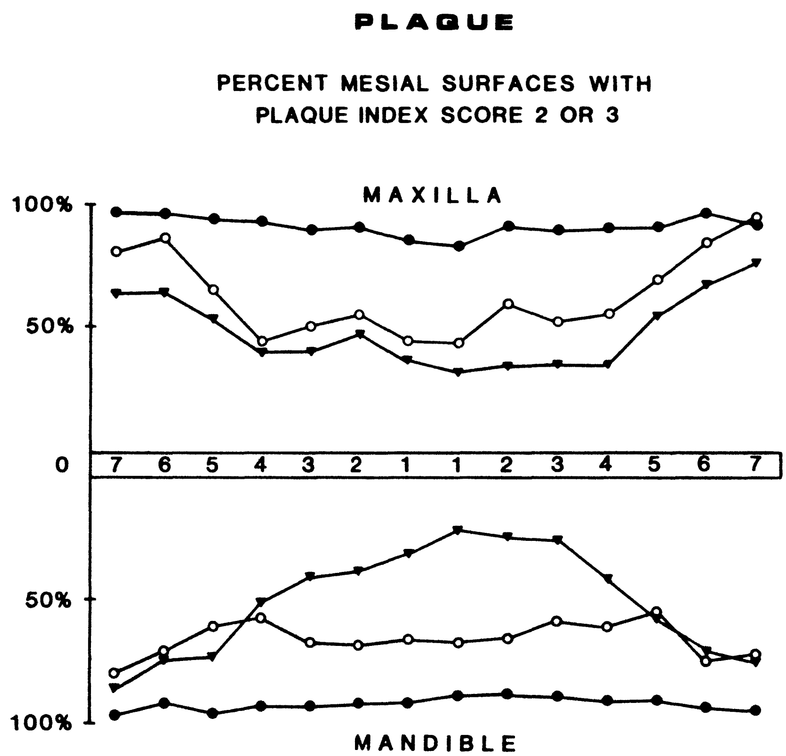

Figure 2.

Percentage distribution of Plaque Index scores of 2 or 3 on mesial surfaces on all teeth for all age groups in the U.S.A. (o), Norway (▾) and Sri Lanka (●).

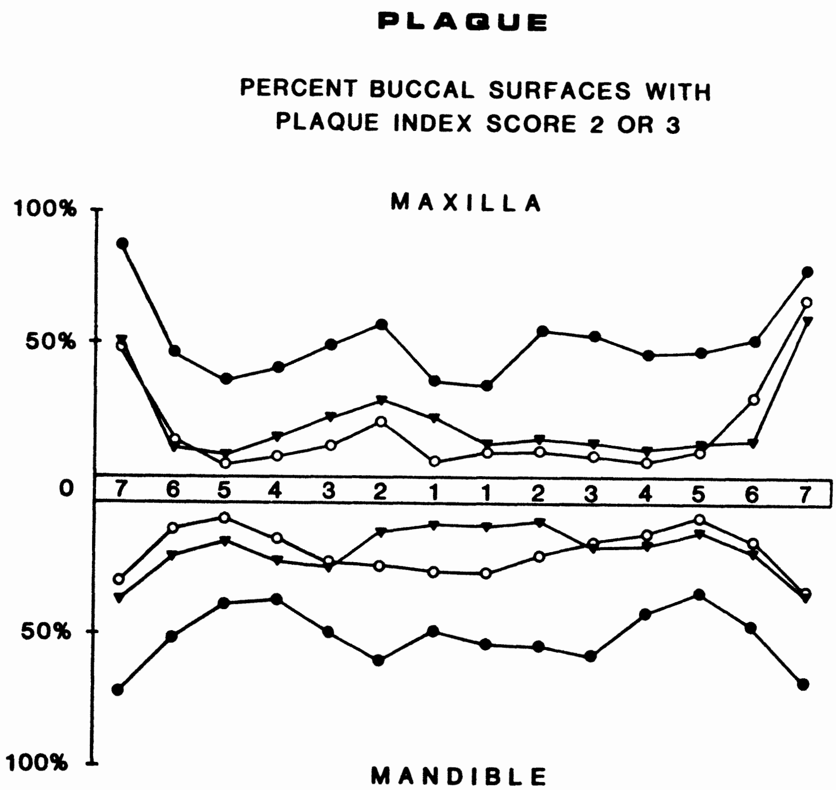

Figure 3.

Percentage distribution of Plaque Index scores of 2 or 3 on buccal surfaces on all teeth for all age groups in the U.S.A. (o), Norway (▾) and Sri Lanka (●).

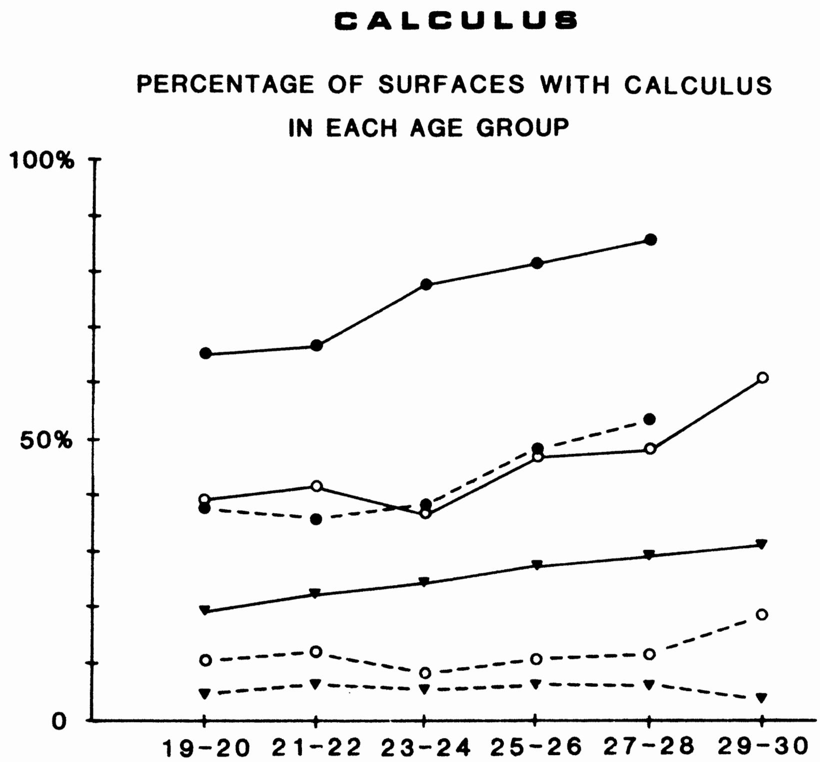

Figure 4.

Percentage of surfaces with supragingival and/or subgingival calculus (CI greater than 0) on mesial and buccal surfaces for each age group in all three populations.

o——o = U.S.A., mesial o- - o = U.S.A., buccal
▼——▼ = Norway, mesial ▼- - ▼ = Norway, buccal
●——● = Sri Lanka, mesial ●- - ● = Sri Lanka, buccal

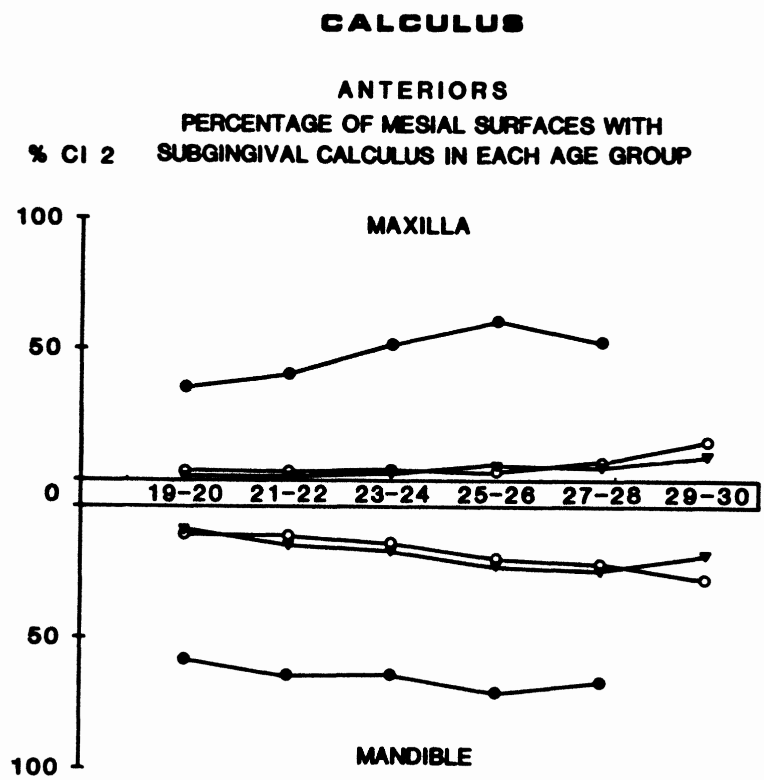

Figure 5.

Percentage of mesial surfaces with subgingival calculus on anterior teeth by age group in the U.S.A. (o), Norway (▾) and Sri Lanka (●).

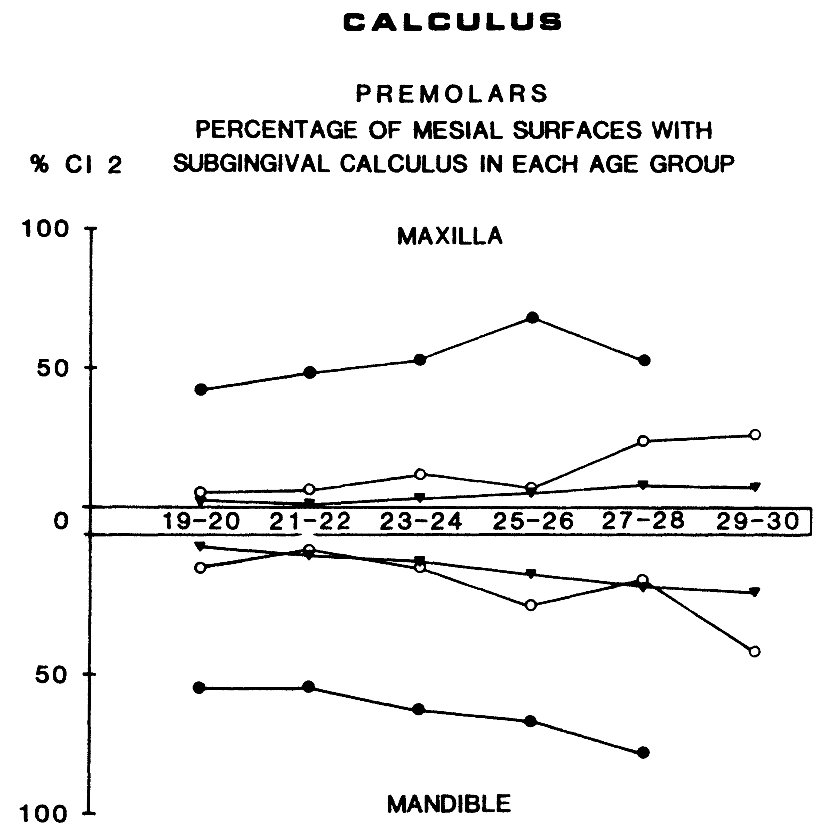

Figure 6.

Percentage of mesial surfaces with subgingival calculus on premolars by age group in the U.S.A. (o), Norway (▼) and Sri Lanka (●).

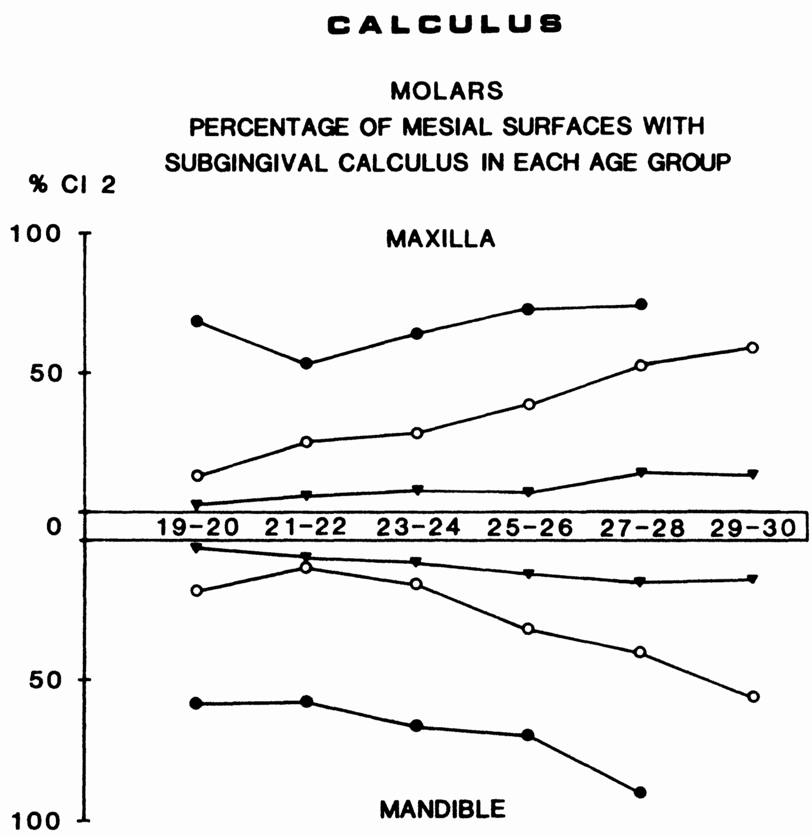

Figure 7.

Percentage of mesial surfaces with subgingival calculus on molars by age group in the U.S.A. (o),Norway (▾) and Sri Lanka (●).

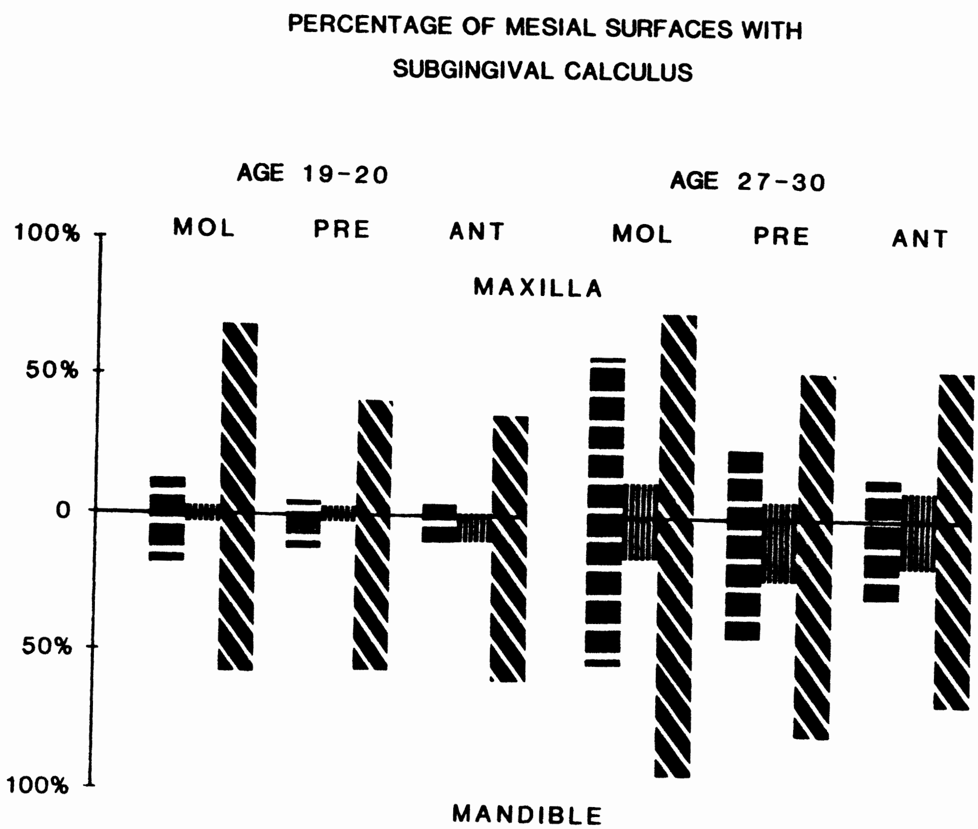

Figure 8.

Percentage of surfaces with subgingival calculus by tooth group in the 19-20 and 27-30 year age group in the U.S.A. ( ), Norway ( ) and Sri Lanka ( ).

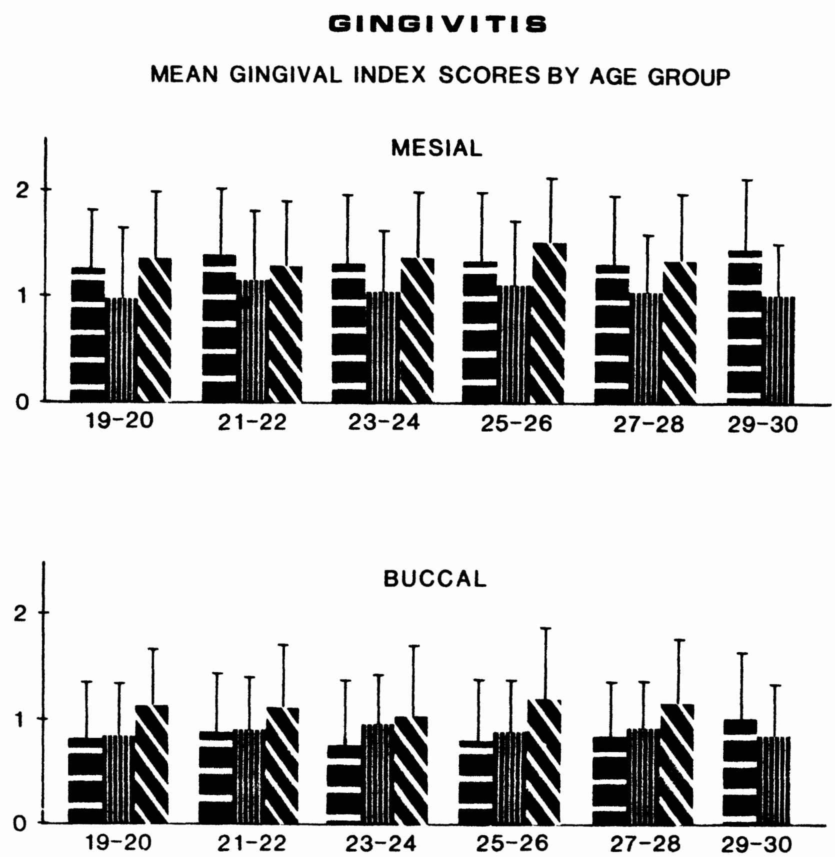

Figure 9.

Mean Gingival Index scores and standard deviations for mesial and buccal surfaces by age group in the U.S.A. ( ), Norway ( ) and Sri Lanka ( ).

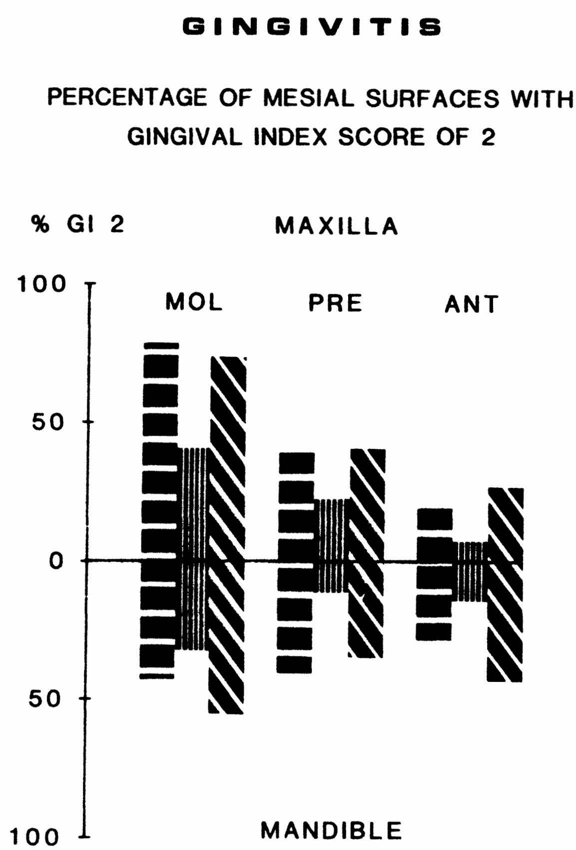

Figure 10.

Percentage of Gingival Index scores of 2 in all subjects on mesial surfaces of molar, premolar and anterior teeth in the U.S.A. ( ), Norway ( ) and Sri Lanka ( ).

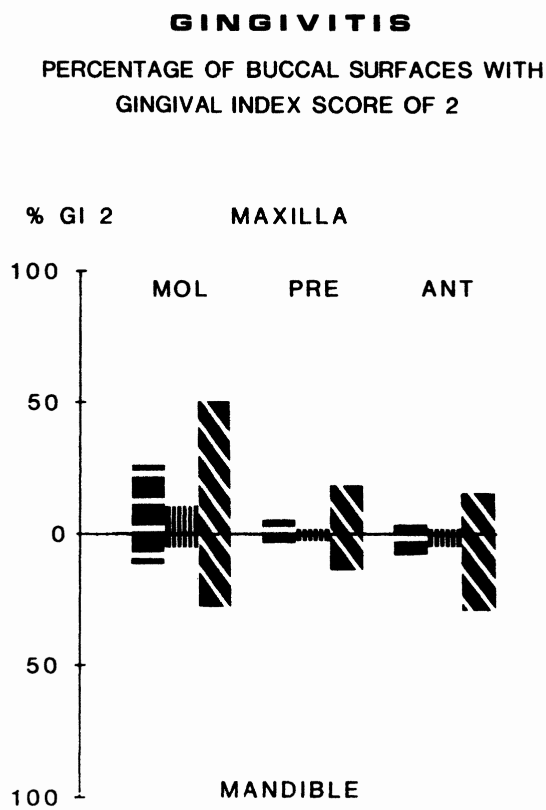

Figure 11.

Percentage of Gingival Index scores of 2 in all subjects on buccal surfaces of molar, premolar and anterior teeth in the U.S.A. ( ), Norway ( ) and Sri Lanka ( ).

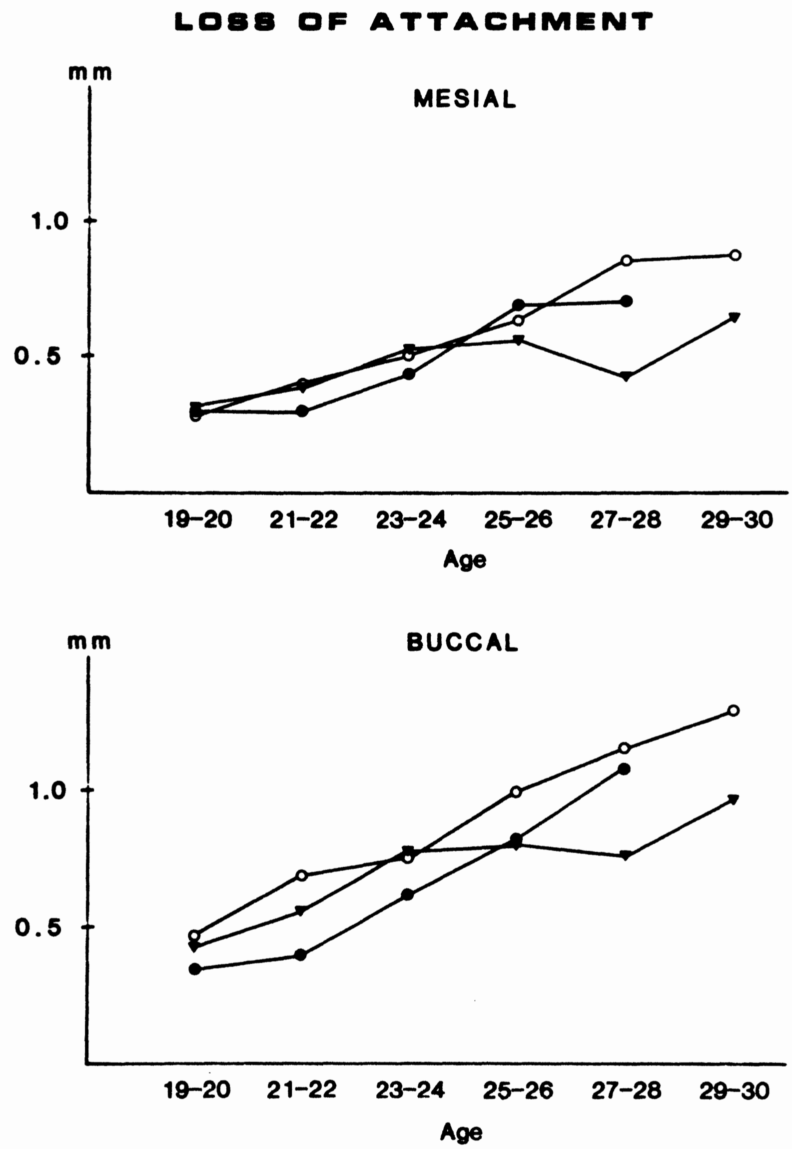

Figure 12.

Mean Loss of Attachment on mesial and buccal surfaces by age group in the U.S.A. (○), Norway (▼) and Sri Lanka (●).

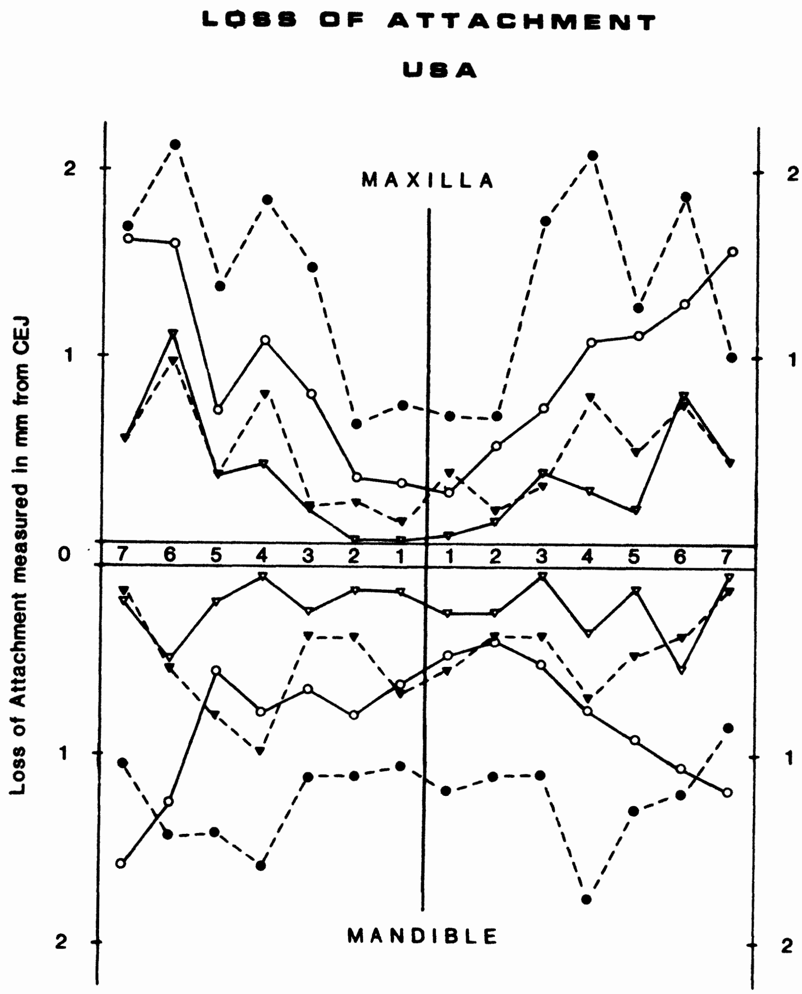

Figure 13.

Distribution of mean Loss of Attachment on mesial and buccal surfaces of all teeth in the 19-20 and 29-30 year age group in the U.S.A.
▼- -▼= buccal, ▽—▽= mesial in 19-20 year age group.
●- -●= buccal, o—o= mesial in 29-30 year age group.

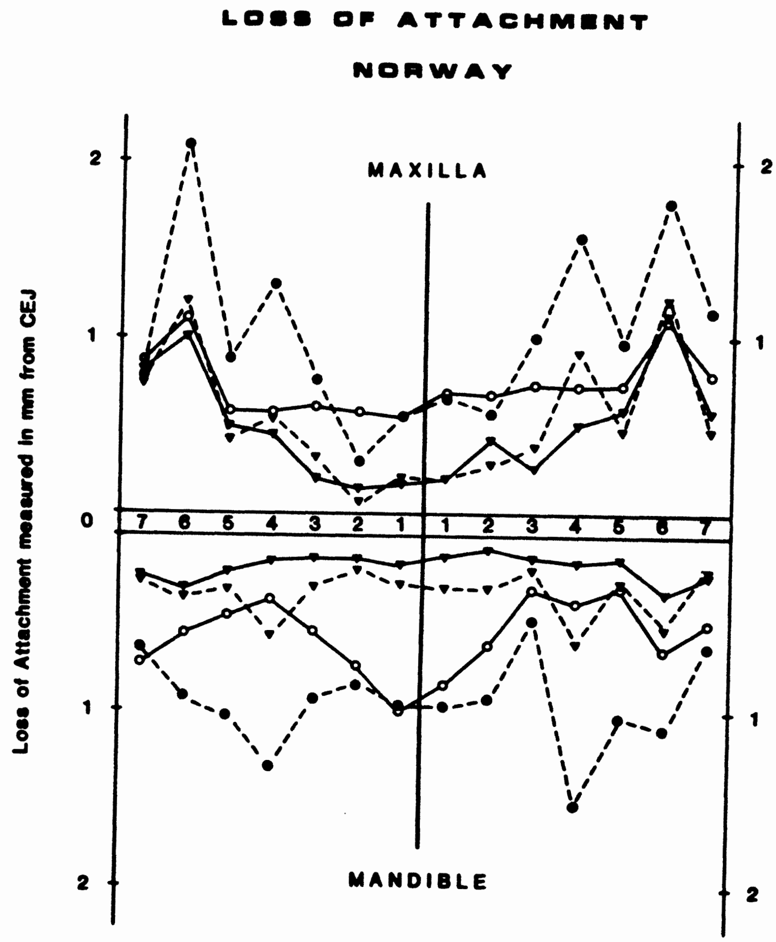

Figure 14.

Distribution of mean Loss of Attachment on mesial and buccal surfaces of all teeth in the 19-20 and 29-30 year age group in Norway.

▼- -▼= buccal, ▽—▽= mesial in 19-20 year age group.
●- -●= buccal, ○—○= mesial in 29-30 year age group.

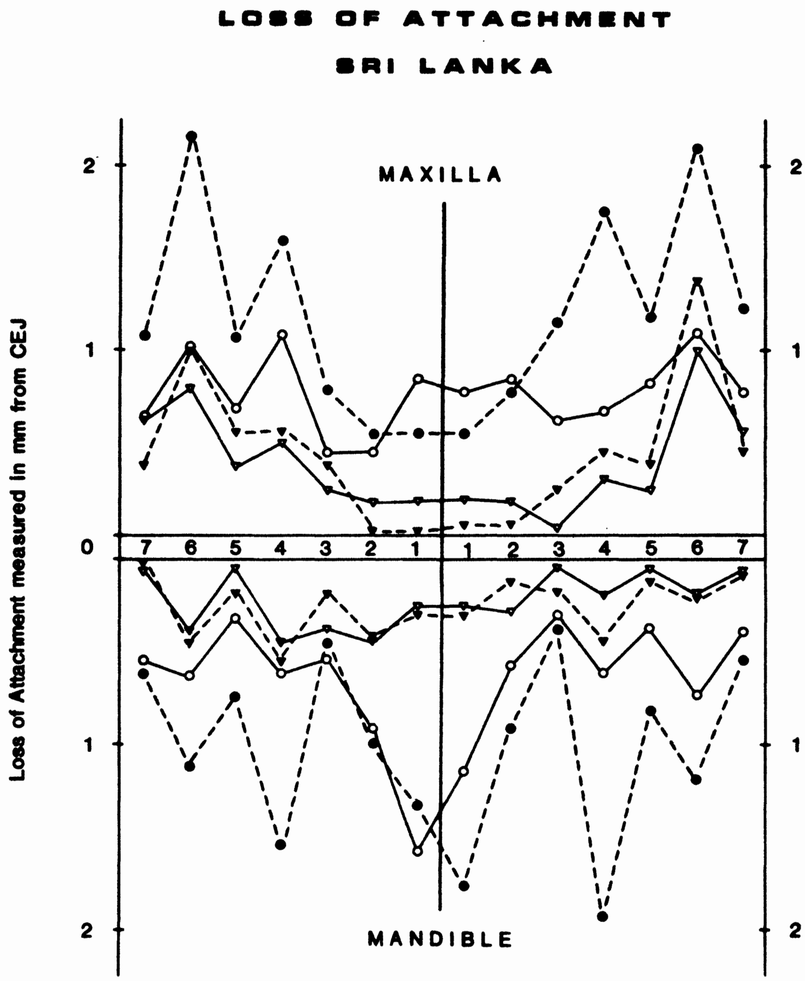

Figure 15.

Distribution of mean Loss of Attachment on mesial and buccal surfaces of all teeth in the 19-20 and 27-28 year age group in Sri Lanka.
▼- -▼= buccal, ▽—▽= mesial in 19-20 year age group.
●- -●= buccal, ○—○= mesial in 27-28 year age group.

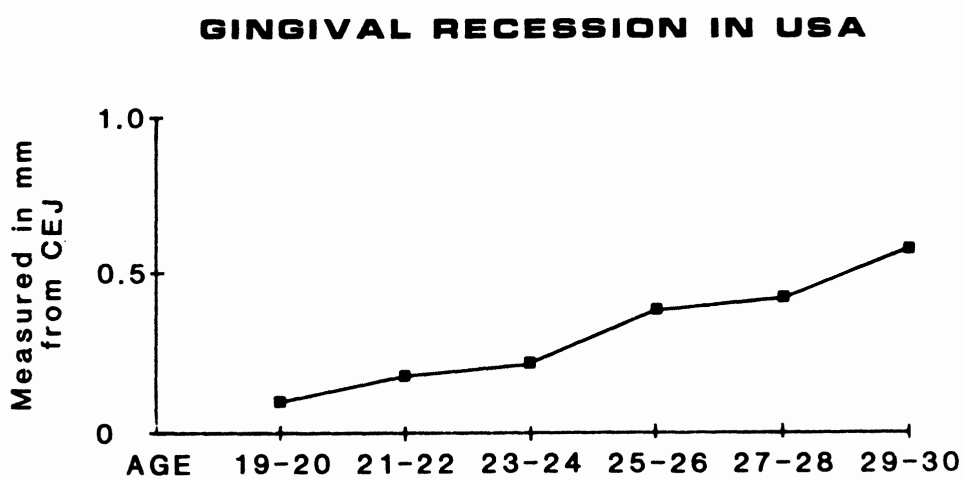

Figure 16.

Mean Gingival Recession on buccal surfaces by age group in the U.S.A.

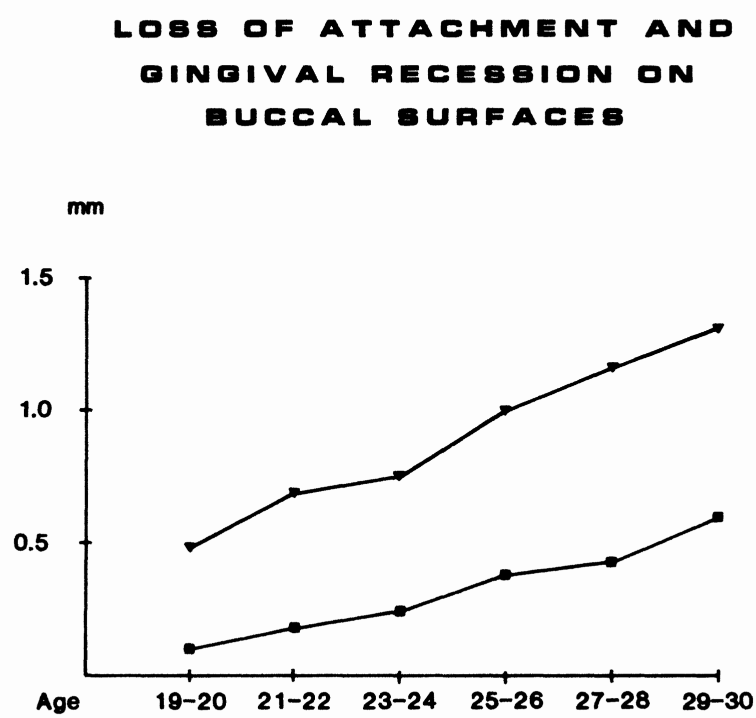

Figure 17.

Mean Loss of Attachment and Gingival Recession on buccal surfaces by age group in the U.S.A.

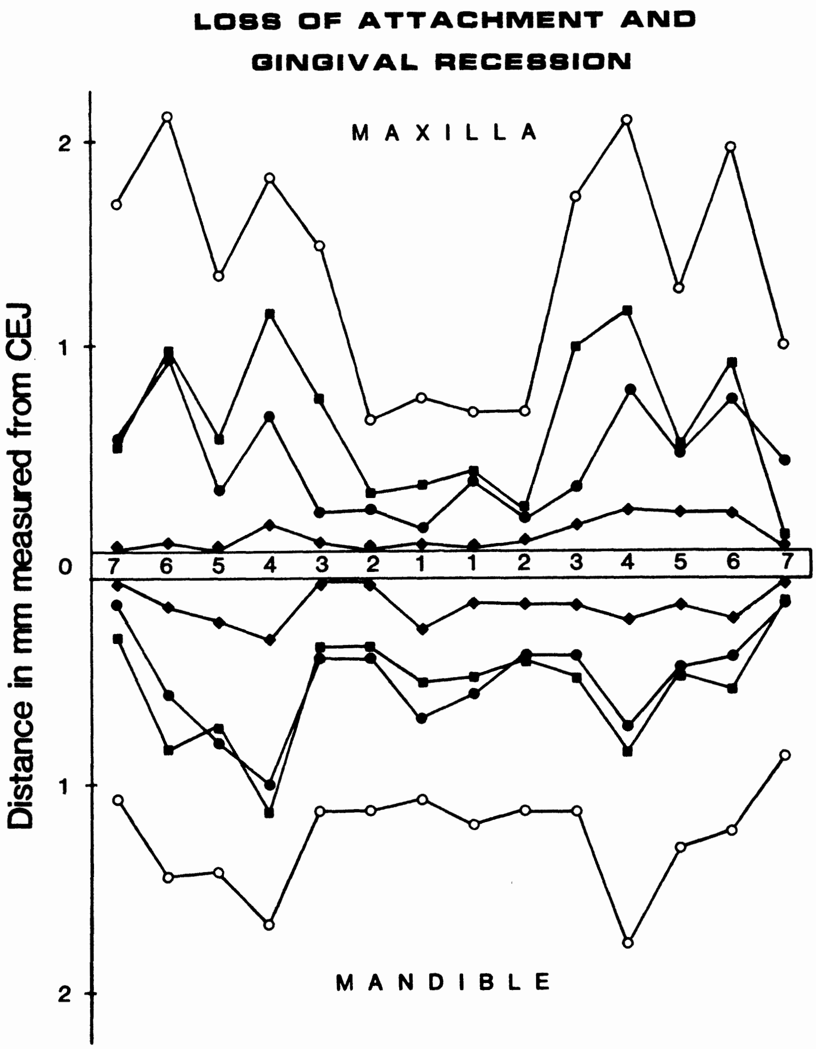

Figure 18.

Mean Loss of Attachment and Gingival Recession on buccal surfaces of all teeth in the U.S.A. for the 19-20 and the 29-30 year age group.

o——o = Loss of Attachment in 29-30 year age group.
■——■ = Gingival Recession in 29-30 year age group.
●——● = Loss of Attachment in 19-20 year age group.
◆——◆ = Gingival Recession in 19-20 year age group.

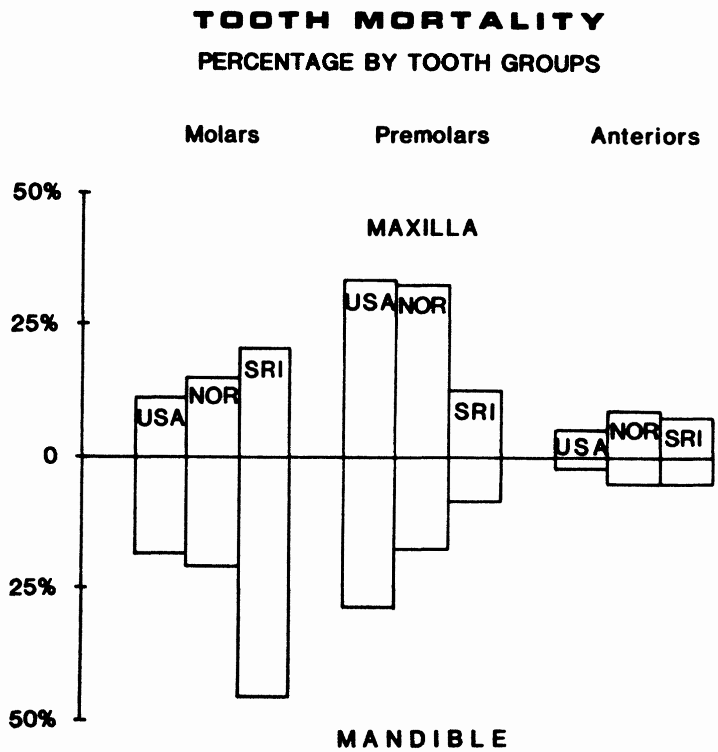

Figure 19.

Percentage distribution of the total number of missing molar, premolar and anterior teeth in the U.S.A., Norway (NOR) and Sri Lanka (SRI).